ALCOA STRUCTURAL HANDBOOK

ALCOA
ALUMINUM

ALUMINUM COMPANY OF AMERICA

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ALUMINUM COMPANY OF AMERICA
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NOTICE

MANY of the materials or their uses, the alloys or their processes of fabrication or casting, their heat treatment or the products of one or more of these operations mentioned in this handbook are covered by United States patents.

FOREWORD

The diversity of form and service characteristic of aluminum alloy structures emphasizes the need for a new design approach. This edition of the Alcoa Structural Handbook presents fundamental design information regarding the strength of aluminum structural members. These data presented through discussion, examples and tables are based on laboratory investigation, field tests and extensive practical experience.

Recent improvements in Alcoa aluminum alloys and structural products together with advances in design methods are reflected in the revision of all sections of the handbook.

The calculations involved in the preparation of this book are based upon the theoretical cross-sections as shown in the tables. It should be noted, however, that in practice these sections vary according to the commercial tolerances shown in the tables.

The services of the research and development facilities of Aluminum Company of America are available to customers who desire assistance in the application of aluminum to their products. Recommendations on design, choice of alloy and commodity, and fabrication are furnished without cost to the customer.

Aluminum Company of America assumes responsibility for the quality of its product but does not assume responsibility for customers' designs or for the performance of structures or parts made in accordance therewith.

The extent of responsibility assumed by Aluminum Company of America is set forth in detail in the company's formal warranty clause which appears on all acknowledgements of its orders and which is quoted in full on page 208 of this book.

CHARACTERISTICS, MANUFACTURE AND FABRICATION OF ALUMINUM ALLOY STRUCTURAL PRODUCTS

PHYSICAL AND MECHANICAL PROPERTIES OF ALUMINUM ALLOY STRUCTURAL PRODUCTS

ALUMINUM ALLOYS are used in structures chiefly because they combine light weight with strength. This combination permits the building of lightweight structures from members possessing the advantages inherent in generous dimensions and bulk. Furthermore, any well-equipped shop can fabricate aluminum alloy structures with no major change of method or equipment.

Structural members and materials are available commercially in a variety of aluminum alloys and in forms adapted to a wide range of use. The alloys commonly used for different structural commodities are given in Table 1, page 21.

From the mining of the ore to final inspection, each step in the manufacture of Alcoa Aluminum Alloy products is under accurate control. This, combined with rigid testing routine for all products, insures uniform quality of the materials produced by Aluminum Company of America. The production, metallurgy, fabrication and testing of Alcoa Aluminum and its alloys is covered in detail in the literature listed on page 212.

WROUGHT ALLOYS

Nomenclature and Products

The wrought alloys of Alcoa Aluminum are produced by rolling, extruding, drawing or forging. They are designated by a combination of numbers and letters which indicate chemical composition, class of material and temper. A detailed discussion of this system of nomenclature is published in "Alcoa Aluminum and Its Alloys." The structural engineer is seldom concerned with many different alloys or tempers. The following examples indicate the general significance of the terms in alloy designations.

The alloy most widely used in aluminum structures is 61S-T6. The first number, "61," identifies the chemical composition; the letter "S" distinguishes this as a wrought, rather than a cast product; the letter "T" shows that the metal has been heat treated to increase strength; and the final "6" defines the method of heat treatment.

Other heat-treated alloys frequently used for structural purposes are 14S-T4 and 14S-T6. These two are similar in all respects except that the T6 temper has been subjected to additional heat treatment thus providing maximum strength.

For low-stressed applications, such as wall or roof panels, nonheat-treatable alloys including 3S-H14 or 4S-H32 often provide maximum economy because of low unit cost and excellent forming characteristics. Taking 4S-H32 as an example, the combination "4S" identifies composition and class, as in the heat-treated alloys; the letter "H" signifies that temper is produced by cold rolling, rather than heat treatment; the final number "32" defines the temper and, consequently, the physical properties.

Certain sheet and plate alloys are produced with an alclad coating which ensures maximum resistance to corrosion. The coating is usually about 5% of the total thickness and can be applied to one or both sides. The surface coating is of an aluminum alloy which is anodic to the core and is bonded to the core by an alloying action at the interface during hot-working and subsequent fabricating operations.

Wrought aluminum alloy products are available in the form of shapes, plate, sheet, bar, tubing, rod, wire, forgings, rivets, bolts, nails and all other forms required for structural purposes.

Nominal Compositions

The nominal compositions of wrought Alcoa Aluminum Alloys used for structural purposes are given in Table 2, page 22. The maximum amount of alloying element added in any of these is about 6 to 7 per cent.

Mechanical Properties

Commercially pure aluminum weighs 0.098 pound per cubic inch and, fully annealed, has a yield strength of about 5000 pounds per square inch. The weight of the wrought alloys used for structural purposes varies from 0.096 pound per cubic inch to 0.101 pound per cubic inch. By means of alloying and heat treatment, the yield strength can be increased to 58,000 pounds per square inch or more. Based on commercially pure aluminum, the variation in weight of the different alloys is less than 4 per cent, while the increase in yield strength may be more than 1000 per cent. In some of the alloys the specific gravity is less than that of commercially pure aluminum.

The typical mechanical properties of the Alcoa Aluminum Alloys used for structural purposes are tabulated on page 23.

Tensile strengths, yield strengths, and elongations of structural Alcoa Aluminum Alloys at elevated temperatures are given in Table 7, page 27. These data provide some measure of the ability of the various alloys to withstand prolonged exposure at elevated temperatures. For specific information concerning the suitability of the various alloys for use at elevated temperatures, the nearest sales office of the Aluminum Company of America should be consulted.

Modulus of Elasticity

The moduli of elasticity of the aluminum alloys included in this book range from 10,000,000 to 10,600,000 pounds per square inch. An average value of 10,300,000 pounds per square inch is suitable for design purposes and is used throughout the book. Modulus of elasticity is important in studies of structural stability as well as in the design of beams and compression members. Deflection under load is dependent on both the form and arrangement of members as well as on the modulus of elasticity of the material. Desired stiffness can be provided by choosing a suitable form of member and by correct distribution of metal. A low modulus of elasticity tends to cushion the shock of impact and decreases the magnitude of stresses set up by misalignment of structural members.

Repeated Stress

The resistance of metals to repeated stress is ordinarily measured by a value known as endurance limit. Endurance limit is the highest stress at which a metal will withstand an indefinitely large number of complete reversals of stress, tension to compression. This endurance limit has little significance in structural design, because loading conditions which produce complete reversal of maximum stress seldom occur in structures. It is sometimes desirable to investigate the possibility of fatigue action at some lower number of cycles than that indicated by the endurance limit. Table 5, page 25, presents data obtained on specimens tested in the R. R. Moore rotating-beam fatigue machine in which only the extreme fiber is subjected to the maximum stress in each cycle. The approximate maximum stresses which the materials will withstand are given for various numbers of cycles. The values in the last column of Table 5, corresponding to 500,000,000 cycles of completely reversed stress, are the endurance limits for the various Alcoa Aluminum Alloys.

The data in Table 6, page 26, were obtained on a direct tension-compression testing machine in which a much wider range of stress variation is produced than is possible in the rotating-beam type of machine. On the direct tension-compression testing machine, the entire cross-section of the specimen is subjected to the maximum stress in each cycle. This difference in stress distribution is responsible for the fact that, for comparable tests in complete reversal, the direct tension-compression results are always somewhat lower than those obtained by the rotating-beam test.

Thermal Expansion

The coefficient of thermal expansion of the wrought aluminum alloys used for structural purposes varies from 0.0000114 to 0.0000128 inch per inch per degree Fahrenheit. Thermal expansion must be considered in relation to the behavior of large structures and in the measurement of long structural members. Table 8, page 28, gives the change in length of wrought Alcoa Aluminum Alloys corresponding to changes in temperature. In aluminum structures, secondary stresses resulting from temperature changes are less than those in similar steel structures, because the lower modulus of elasticity of aluminum compensates for its greater coefficient of thermal expansion.

Electrical and Thermal Conductivity

The electrical and thermal conductivities of aluminum alloys vary with alloy, heat treatment and amount of strain hardening. The high thermal conductivity of aluminum alloys makes it possible to use hot-driven rivets in heat-treated aluminum alloys without damage to mechanical properties.

Resistance to Corrosion

Aluminum alloys used for structural purposes have good resistance to atmospheric corrosion. This decreases the cost of maintenance and increases the safety of structures made of them. Corrosion may occur under severe conditions; and in such locations, aluminum structures, like those made of other materials, should have adequate paint protection. This is particularly true for structures which may be subjected to the corrosive agents that occur in mine waters or in certain industrial processes.

MANUFACTURE OF WROUGHT ALLOY PRODUCTS

The methods of manufacturing Alcoa Aluminum Alloy structural materials vary with the product and alloy. Maximum commer-

cial sizes for the various products are given on pages 188 to 200, and commercial tolerances are shown on pages 171 to 187.

Rolling

Sheet, plate, shapes, rod and bar are produced by rolling. In addition to standard structural shapes such as angles and channels, Aluminum Company of America is in a position to supply special rolled sections. These can be obtained with cross-sectional areas as great as 30 square inches, lengths up to 85 feet, and weights per piece as heavy as 1400 pounds. Thick plate and shapes are flattened and straightened by rolls, while sheet and certain sizes of plate and shapes are straightened by stretching.

Extruding

Extruded shapes are produced by forcing metal through an orifice having the shape of the desired cross-section. The member is then straightened by stretching. There are definite limitations to the weight per foot of length and to the total weight per piece of extruded sections. In general, sections which may be enclosed in a 15-inch circle can be extruded. Larger sections are sometimes produced, and, when these are desired, information may be obtained from the nearest sales office of Aluminum Company of America. Tools required for producing extruded shapes are relatively inexpensive.

Many of the 35,000 extruded sections now produced are useful in supplementing standard structural shapes. Maximum economy of metal and fabricating cost can often be effected by designing members especially adapted to a given purpose, and it is for such that extruded shapes are generally used.

Drawing

Seamless tubing is produced in a variety of alloys and sizes. The commercial range of diameters and wall thicknesses of round tubing is given in the table on pages 198 and 199. Oval, square, rectangular, streamline and special shapes are also available.

Forging

Die and open forgings are made from several aluminum alloys. Forging develops excellent properties in these alloys, and such forgings represent the maximum in combined strength and light weight. Hand forgings weighing over 2000 pounds have been made, and intricate shapes are produced in smaller die forgings.

Heat Treating

The solution heat treatment of wrought alloys consists of heating at carefully controlled temperatures, varying from 910°F. to 1000°F. for different alloys, and quenching. The time of heating depends on the size of load in the furnace and the thickness of the material. The sudden change in temperature, caused by the quench, may result in some distortion of the piece. This distortion is removed by subsequent rolling or stretching operations, but it must be given careful consideration where solution heat treatment is contemplated on a preformed member. The solution heat treatment is followed by an aging or precipitation heat treatment at room temperature for some of the alloys, and at temperatures varying from 315°F. to 365°F. for others. This aging treatment does not produce severe deformations of the material.

FABRICATION OF ALUMINUM ALLOY STRUCTURES

Forming

Through proper choice of alloy, bend radii and tools, a great variety of forming operations can be performed on aluminum alloys. Ordinary types of presses, brakes or rolls are suitable for this work, but it is highly desirable that the surfaces of the tools which come in contact with the aluminum alloys be smooth and free from tool marks, dents or rough edges which would tend to tear or score the metal. For difficult operations, lubricants, such as heavy oils or tallow mixed with a small amount of mineral oil, can be used to advantage.

The surface and edges of the metal to be bent should be smooth. Scratches, nicks and sharp corners should be removed. A pencil or crayon, rather than a punch or scriber, should be used for marking bend lines.

Shape of section and thickness of metal determine the severity of forming which can be accomplished successfully for a given alloy and temper. Table 9, page 29, indicates the cold bend radii which are commonly used for various Alcoa Alloys and thicknesses of sheet or plate. These values have been established by tests and practical experience, but it is advisable to try out the operation with available tools on sample pieces where a minimum bend radius is necessary.

For cold forming, the severity of the operation, which can be accomplished successfully, decreases as the hardness or strength of an

alloy increases. With the alloys which derive their strength from cold working, the proper alloy and degree of hardness can be selected to assure the success of a given forming operation. For heat-treated alloys, forming can be done either hot or cold on annealed material, and strength developed by subsequent heat treatment. In alloys which are artificially aged, such as 61S, material in the "as quenched" or "T4" temper is much more ductile than the fully heat-treated and aged or "T6" material. Cold forming can be done in the intermediate temper and the member subsequently aged to develop full strength.

Excessive heating of heat-treated material affects temper and reduces strength. At 400°F. the workability of 14S-T4, 14S-T6 and 61S-T6 is much better than at room temperatures, and providing this temperature is maintained for not more than a few minutes, there is no harmful effect on the properties of the metal. The use of this method of forming 24S-T4 is undesirable as the resistance to corrosion may be impaired. Where forming at 400°F. is attempted, it is important that a frequent check of metal temperature be made with an accurate contact pyrometer.

Machining

Machining operations can be performed, using the same methods and equipment as with steel, but for best results cutting tools must be specially ground. Tools should have keen edges with more side and top rake than is usual for steel. In all machining operations, a liberal use of a cutting compound is desirable. For detailed discussion, the booklet, "Machining Alcoa Aluminum," should be consulted.

Shearing

Aluminum alloy sheet, plate and shapes ½ inch or less in thickness can be sheared on any of the types of equipment used for steel. Blades should be sharp and clearances adjusted to give smooth cuts. Material thicker than ½ inch should be sawed.

Sawing and Routing

Straight, curved and coping cuts can be made by saws. Lubricants of the soluble oil type are recommended. For straight cuts, stationary or portable circular saws are used, while band saws are used for curved or coping cuts. In any type of work, high blade speeds are desirable. A speed of 5000 feet per minute is recommended for band saws, while a peripheral speed of 10,000 feet per minute gives good results with circular saws. The saw teeth should be fairly

coarse with a slight set and a slight amount of front rake. Special routing machines are available which cut varied profiles from aluminum sheet or plate rapidly and efficiently.

Punching, Reaming, Drilling

Rivet or bolt holes in primary-load-carrying members should be drilled or subpunched and reamed. On material over ½-inch thick, all holes should be drilled. Both single- and multiple-type punches such as are used on structural steel are suitable for aluminum alloys. The punch should be accurately centered in the die with a radial clearance of about $\frac{1}{32}$ inch. Cutting edges of both punches and dies should be sharp. In punching tread plate, the punch should enter from the pattern surface of the plate. For rivets of ⅝-inch diameter or larger, holes should be subpunched ⅛ inch less than the nominal diameter of the rivet and reamed to finished size of not more than $\frac{1}{32}$-inch greater diameter than the nominal rivet size.

Reamers should be of the high-speed, spiral-fluted type. Reaming operations on aluminum alloys are about twice as fast as the same work in steel.

Twist drills used on aluminum alloys should be kept sharp and constantly lubricated with a soluble oil. Drill speeds can be increased about 50 per cent above those used for steel. Special drills with more than the normal number of twists per inch can be used to advantage where a large amount of work is to be done. A double-fluted twist drill with a spiral angle of 47° gives good results on aluminum alloys.

Riveting

Aluminum alloy rivets are preferred for the fabrication of aluminum alloy structures. Information on the dimensions and strength of aluminum alloy rivets is given on pages 66 and 155. In any riveting operation, it is desirable that the clearance of the rivet in the hole be held to a minimum.

Aluminum alloy rivets should be used in structures where high resistance to corrosion or uniform appearance, with the elimination of possible rust stains, is desired.

Squeeze-type riveters should be used on aluminum rivets where possible. Pneumatic hammers and back-up tools should be heavier than those used for steel rivets of the same size. The flat cone type of driven head shown on page 155 facilitates driving and has a good appearance.

Cold driving is used for 53S-T61, 61S-T6 and A17S-T4 alloy rivets as received from the manufacturer. Rivets with flat cone heads in sizes up to ⅝-inch diameter are readily driven with a pneumatic hammer. Large rivets should be squeeze driven.

Cold driving is also used for 17S and 24S alloy rivets where proper heat-treating equipment is available. Such rivets should be heat treated, quenched and driven immediately to take advantage of the workability of the metal before age hardening occurs at room temperature. This "as quenched" workability can be retained for 8 to 10 hours by refrigerating to 32°F. or less and storing at this temperature until use. Such cold driving is normally restricted to sizes of less than ½-inch diameter.

Hot driving is often desirable for rivets over ½ inch in diameter since driving pressures are only ⅓ to ⅕ as great as for corresponding cold rivets. For hot driving, 53S rivets should be brought to a temperature of 1030°F. to 1050°F. in a furnace having accurate temperature control. Rivets must be transferred from the furnace to the work and driven in the least possible time as quenching is obtained by contact with cold metal and tools. Rivets of 17S and 61S alloy can be hot driven using a similar procedure except that the heating range is 930°F. to 950°F. for 17S and 990°F. to 1050°F. for 61S.

Standard steel fabricating practice is followed in driving hot steel rivets in aluminum alloy structures. Annealed steel rivets are driven cold in sizes up to 1-inch diameter. Flat or cone-type heads are used, and results are satisfactory in quality and economy, provided an edge distance of at least two diameters is maintained. For cold-driven steel rivets over ½ inch in diameter, the squeeze-type riveter must be used.

Experience with many riveting operations, on all types of structures of heat-treated aluminum alloys, has proved that distortion is no greater than in steel structures. When riveting the softer grades of aluminum, special care must be exercised to avoid overdriving. The driven head should, where possible, be formed on the side of the work having the greater thickness or hardness of metal. For the details of riveting operations on aluminum alloys, refer to the booklet, "Riveting Alcoa Aluminum."

Welding

Certain alloys of aluminum may be welded by torch, electric arc and resistance welding methods. Welding tends to decrease the strength of tempered material because of the annealing effect. In

some cases satisfactory results can be obtained by the heat treatment of parts after welding. Welding processes for aluminum alloys are being developed rapidly. The booklet, "Welding and Brazing Alcoa Aluminum," gives much valuable information on this subject.

Burning

Flame-cutting should not be attempted with aluminum alloys. The excessive heat damages the metal and the cut edge is very ragged. The metal melts instead of burning.

Painting

Although aluminum and its alloys do not rust, it is frequently desirable under severe conditions of exposure to protect them with paint as in the case of other metals, especially where thin sections are employed. For ordinary conditions of use such as bridge floors, flood bulkheads and excavator booms, the finishing system used on steel structures may generally be employed with some changes in the surface preparation and priming coat.

It is important that surfaces be properly prepared before painting. One satisfactory method is to treat the surface with a solution of phosphoric acid combined with special grease solvents. A number of such mixtures for chemical treatment are commercially available. In using treatments of this type the manufacturer's directions should be followed and the surface thoroughly rinsed with clean water after treating in the solution. For many conditions of use it may be found unnecessary to employ any special surface preparation other than to remove accumulations of grease or dirt by means of washing with a solvent.

As a priming coat, a paint containing a substantial proportion of zinc chromate has been found to be most effective. Where possible, the pigment portion of the primer should consist substantially of zinc chromate with a small amount of inert pigment. For the finishing coat, aluminum paint is the most durable, but where other colors are desired, any durable finishing paint may be employed.

Paint coatings may be applied to aluminum surfaces by employing practically the same procedure and equipment as in the case of steel or other metallic surfaces.

For a more complete discussion of the use of paints on aluminum, refer to the booklet, "Finishes for Alcoa Aluminum."

CASTING ALLOYS

Aluminum alloy castings are suitable for many structural applications. In certain cast alloys, the mechanical characteristics are obtained by alloying alone and the material is designated by the term "as cast." In other alloys, the properties are improved by heat treatment. The chemical composition of casting alloys of Alcoa Aluminum is designated by a number, while the heat treatment is designated by the letter "T" followed by a number, e.g., 220-T4. The nominal compositions of several casting alloys most suitable for structural uses are given in Table 2, page 22.

Mechanical Properties

Mechanical properties of Alcoa Aluminum sand-casting alloys are shown in Table 4, page 24. These values have been determined from standard ½-inch diameter test specimens individually cast in green-sand molds and tested without machining off the surface. As is the case with the other cast metals, the properties so determined are not necessarily the same as those of test bars cut from commercial castings, but may be higher or lower. In the design of castings, the services of the engineering and technical staff of Aluminum Company of America are available on request. The booklet entitled "Casting Alcoa Alloys" will also prove useful.

For structural purposes most aluminum alloy castings are made in sand molds. Patterns used for other metals can often be modified for aluminum alloy castings, but sometimes differences in shrinkage and foundry methods require special patterns. Single castings weighing over 3500 lb. have been produced in aluminum alloys.

SELECTION OF ALLOY

The selection of the proper alloy for a specific structural application depends on the requirements of strength, durability and economy and is limited by proposed fabricating methods and by availability of the commodities required. Table 1, page 21, will assist the engineer in making a preliminary selection. Stocks of certain items are available for immediate shipment; other material is fabricated to order. Before specifying aluminum alloy materials the engineer should consult the nearest sales office of Aluminum Company of America.

TABLES OF CHARACTERISTICS, COMPOSITION AND MECHANICAL PROPERTIES OF ALUMINUM ALLOYS USED FOR STRUCTURAL PURPOSES

Definitions and Significance of Terms used in Tables of Mechanical Properties. General Data.

1. For all Alcoa Alloys, wrought and cast, the following approximate data apply:

   (a) Modulus of elasticity (E).....10,300,000 pounds per square inch[1]

   (b) Modulus of rigidity (G)...... 3,850,000 pounds per square inch[1]

   (c) Poisson's ratio................0.33

2. Yield strength is the stress which produces a permanent set of 0.2 per cent of the initial gage length (American Society for Testing Materials' Standard Methods of Tension Testing—E8-46).

3. Endurance limits are based on 500,000,000 cycles of completely reversed stress, using the R. R. Moore type of machine and specimen.

4. Elongation varies with the form and size of test specimen. When round specimens are used the gage length for the measurement of elongation is equal to four times the diameter of the reduced section of the specimen.

5. Dimensions given in tables for the following products are as listed below:

   Sheet and plate......Thickness

   Tubing.............Outside diameter

   Forgings............Diameter or thickness

   Rod and bar........Diameter or least distance between parallel surfaces, or where so stated maximum area of cross-section. Maximum size of hexagon is 2 inches; of octagon, 1$\frac{3}{16}$ inches; of square, 4 inches.

[1]The values of E and G vary somewhat with the alloy, and E is about 2 per cent higher in compression than in tension. Some specific values of E and G are as follows, those for E being the average of tension and compression:

Alloy	E lb./sq. in.	G lb./sq. in.
3S, 4S, 61S	10,000,000	3,800,000
A51S, 52S	10,200,000	3,850,000
14S, 24S	10,600,000	4,000,000

TABLE 1—CHARACTERISTICS OF ALUMINUM ALLOYS USED FOR STRUCTURAL PURPOSES

Alloy	Usual Commercial Tempers[1]	Standard Commodities	Outstanding Characteristics	Typical Uses
3S	O to −H18	Sheet, plate, wire, rod, bar, extrusions, tubing, forgings.	Workability, weldability[4], resistance to corrosion.	Sheet metal work, tanks, piping, chemical equipment.
4S	O to −H38	Sheet, plate, tubing.	Higher strength than 3S, weldability[4], resistance to corrosion.	Sheet metal work, roofing, siding.
52S	O to −H38	Sheet, plate, wire, rod, bar, tubing.	Higher strength than 4S, weldability[4], very high resistance to corrosion.	Sheet metal work in the marine field.
14S	−T4 and −T6	Shapes, extrusions, forgings, sheet[2], plate[2].	High strength and hardness.	General purpose high strength structural alloy, bridges, booms, forgings.
24S[3,5]	−T3 and −T4	Sheet[3], plate[3], wire, rod, bar, extrusions, tubing, rivets.	High strength, limited workability.	Aircraft.
A51S	−T6	Forgings.	Good strength, excellent forgeability.	Intricate forgings for machine and automotive parts.
61S	−T4 and −T6	Sheet, plate, wire, rod, bar, shapes, extrusions, tubing.	Good strength, best cold workability of heat-treated alloys, weldability[4], resistance to corrosion.	Most widely used structural alloy. Switchyard structures, tank roofs, marine applications, pipe.
43	As cast	Castings.	Weldability and resistance to corrosion, good castability.	Architectural spandrels, sewage disposal plants, miscellaneous small castings, valves.
214	As cast	Castings.	Good strength and resistance to corrosion.	Marine applications, machine parts, pipe fittings.
195[5]	−T6	Castings.	High strength and good shock resistance.	Miscellaneous machine parts and stressed castings.
356	−T6	Castings.	Weldability[4], pressure tightness, resistance to corrosion, good castability.	Intricate strength castings, marine field, pipe fittings, valves.
220[5]	−T4	Castings.	Highest strength and shock resistance of casting alloys, resistance to corrosion.	Heavy-duty castings subject to high loads and impact, machine parts, marine field.

[1]Available temper varies with commodity and size. See Tables 35 to 76.
[2]Alloy 14S sheet and plate is furnished alclad—other commodities nonclad.
[3]Alloy 24S sheet and plate is furnished either alclad or nonclad—other commodities nonclad.
[4]Welding tends to anneal tempered material. See page 17.
[5]Resistance to corrosion impaired by exposure to temperatures above 250°F.

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TABLE 2—NOMINAL COMPOSITION OF ALUMINUM ALLOYS USED FOR STRUCTURAL PURPOSES[1]

	Alloy	Per cent of alloying elements. Aluminum and normal impurities constitute remainder				
		Copper	Silicon	Manganese	Magnesium	Chromium
Wrought	3S	...	...	1.2	...	....
	4S	...	...	1.2	1.0	....
	14S	4.4	0.8	0.8	0.4	....
	24S	4.5	...	0.6	1.5	....
	A51S	...	1.0	...	0.6	0.25
	52S	...	...	...	2.5	0.25
	61S	0.25	0.6	...	1.0	0.25
Cast	43	...	5.0	...	...	....
	195	4.5	0.8	...	...	....
	214	...	...	...	3.8	....
	220	...	...	...	10.0	....
	356	...	7.0	...	0.3	....

[1]Heat-treatment symbols have been omitted since composition does not vary for different heat-treatment practices.

TABLE 3—TYPICAL[1] MECHANICAL PROPERTIES OF WROUGHT ALUMINUM ALLOYS[2]

In Forms Most Generally Used for Structural Purposes

Alloy	Tension			Compression	Hardness	Shear		Fatigue	Weight
	Ultimate Strength Lb./sq. in.	Yield Strength (Set=0.2%) Lb./sq. in.	Elongation Per Cent in 2 inches. Round Specimen (½-inch diameter)	Yield Strength (Set=0.2%) Lb./sq. in.	Brinell 500 kg., 10 mm. ball	Ultimate Strength Lb./sq. in.	Yield Strength (Set=0.2%) Lb./sq. in.	Endurance Limit Lb./sq. in.	Lb./cu. in.
3S-O	16,000	6,000	40	6,000	28	11,000	4,000	7,000	0.099
3S-H12	19,000	17,000	20	17,000	35	12,000	10,000	8,000	0.099
3S-H14	21,500	19,000	16	19,000	40	14,000	12,000	9,000	0.099
3S-H16	25,000	22,000	14	22,000	47	15,000	13,000	9,500	0.099
3S-H18	29,000	26,000	10	26,000	55	16,000	14,000	10,000	0.099
4S-O	26,000	10,000	25	10,000	45	16,000	6,000	14,000	0.098
4S-H32	31,000	22,000	17	22,000	52	17,000	12,000	14,500	0.098
4S-H34	34,000	27,000	12	27,000	63	18,000	14,000	15,000	0.098
4S-H36	37,000	31,000	9	31,000	70	20,000	17,000	15,500	0.098
4S-H38	40,000	34,000	6	34,000	77	21,000	19,000	16,000	0.098
14S-T4[3,5]	62,000	41,000	20	41,000	105	38,000	24,000	20,000	0.101
14S-T6[3]	70,000	60,000	13	60,000	135	42,000	36,000	18,000	0.101
24S-T4[4]	68,000	48,000	19	48,000	120	41,000	28,000	20,000	0.100
A51S-T6	48,000	43,000	17	43,000	100	32,000	26,000	11,000	0.097
52S-O	27,000	12,000	30	12,000	45	18,000	8,000	17,000	0.097
52S-H32	34,000	27,000	18	27,000	62	20,000	16,000	17,500	0.097
52S-H34	37,000	31,000	14	31,000	67	21,000	18,000	18,000	0.097
52S-H36	39,000	34,000	10	34,000	74	23,000	19,000	18,500	0.097
52S-H38	41,000	36,000	8	36,000	85	24,000	21,000	19,000	0.097
61S-O	18,000	8,000	30	8,000	30	12,500	6,000	9,000	0.098
61S-T4	35,000	21,000	25	21,000	65	24,000	14,000	13,500	0.098
61S-T6	45,000	40,000	17	40,000	95	30,000	26,000	13,500	0.098

[1]For guaranteed minimum values, see Tables 35 to 39.
[2]See page 20 for definitions and significance of terms; also additional data.
[3]14S sheet and plate are furnished as alclad material with strengths comparable to the above. All other 14S commodities are furnished nonclad.
[4]24S sheet and plate are furnished as alclad or nonclad material. The strengths of the alclad material are approximately 10 per cent less than those of the nonclad material. All other 24S commodities are furnished nonclad.
[5]As the weight per foot of 14S-T4 rolled structural shapes approaches and exceeds 4 lb./ft., the yield strength decreases about 15 per cent from the listed value.

TABLE 4—MECHANICAL PROPERTIES OF SAND-CAST ALUMINUM ALLOYS[1]

Alloy	Minimum values for specifications		Typical values (not guaranteed)							
	Tension[2]		Tension[2]			Compression[3]	Hardness	Shear	Fatigue	Weight
	Ultimate Strength Lb./sq. in.	Elongation Per Cent in 2 Inches	Ultimate Strength Lb./sq. in.	Yield Strength (Set = 0.2%) Lb./sq. in.	Elongation Per Cent in 2 Inches	Yield Strength (Set = 0.2%) Lb./sq. in.	Brinell 500 kg., 10 mm. ball	Shearing Strength Lb./sq. in.	Endurance Limit Lb./sq. in.	Lb./cu. in.
43	17,000	3.0	19,000	9,000	6.0	10,000	40	14,000	6,500	0.095
195-T4[5]	29,000	6.0	32,000	16,000	8.5	16,000	60	24,000	6,000	0.100
195-T6	32,000	3.0	36,000	24,000	5.0	25,000	75	30,000	6,500	0.100
195-T62	36,000	[4]	40,000	30,000	2.0	38,000	95	31,000	7,000	0.100
214	22,000	6.0	25,000	12,000	9.0	12,000	50	20,000	5,500	0.094
220-T4	42,000	12.0	46,000	25,000	14.0	26,000	75	33,000	7,000	0.091
356-T6	30,000	3.0	33,000	24,000	4.0	24,000	70	27,000	8,000	0.095
356-T51	23,000	[4]	25,000	20,000	2.0	22,000	60	18,000	7,500	0.095

[1]See page 20 for definitions and significance of terms; also additional data.

[2]Tension and hardness values determined from standard half-inch diameter tensile test specimens individually cast in green-sand molds and tested without machining off the surface.

[3]Results of tests on specimens having an L/r ratio of 12.

[4]Not specified. The error in determining low elongations is comparable with the value being measured.

[5]On standing at room temperature for several weeks, the properties of 195-T4 approach those of 195-T6.

TABLE 5—ROTATING-BEAM FATIGUE DATA

All values of stress in lb./sq. in.

Values given were determined by testing 0.3-inch diameter machined specimens in R. R. Moore Rotating-Beam Fatigue Machines and represent extreme fiber stresses which such specimens will withstand in completely reversed flexure.

Alloy and Temper	Approximate maximum stresses which material will withstand for various numbers of cycles				
	100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles[1]
3S-H14	17,000	12,000	10,000	9,000	9,000
3S-H16	17,500	12,500	10,500	9,500	9,500
3S-H18	19,000	14,000	11,500	10,500	10,000
4S-H36	23,000	20,000	18,000	16,000	15,500
14S-T4	42,000	34,000	27,000	22,000	20,000
14S-T6	40,000	32,000	25,000	20,000	18,000
24S-T4	42,000	34,000	27,000	22,000	20,000
A51S-T6	29,000	21,000	15,500	12,500	11,000
52S-O	20,000	19,000	18,000	17,500	17,000
52S-H32	23,000	20,000	18,500	17,500	17,500
52S-H34	26,000	20,500	19,000	18,000	18,000
52S-H36	28,000	21,000	19,000	18,500	18,500
61S-O	16,000	13,000	11,000	9,500	9,000
61S-T4	27,500	22,500	17,500	15,000	13,500
61S-T6	31,000	22,500	17,500	15,000	13,500

[1]Values given for 500,000,000 cycles are commonly known as endurance limits.

TABLE 6—DIRECT TENSION-COMPRESSION FATIGUE DATA

All values of stress in lb./sq. in.

Values given were determined by testing 0.2-inch diameter machined specimens in A.R.L. direct stress fatigue machines and represent uniformly distributed stresses which such specimens will withstand under repeated axial loads.

Stresses considered algebraically: plus (+) means tension, minus (−) means compression.

Alloy	Minimum stress in each cycle	Approximate maximum stresses which material will withstand for various numbers of cycles				
		100,000 cycles	1,000,000 cycles	10,000,000 cycles	100,000,000 cycles	500,000,000 cycles
14S-T4, 24S-T4 alloys	−25,000	+38,000	+26,000	+17,000	+10,000	+ 8,000
	−20,000	+41,000	+30,000	+21,000	+15,000	+12,000
	−15,000	+44,000	+34,000	+24,000	+19,000	+16,000
	−10,000	+46,000	+37,000	+28,000	+23,000	+20,000
	− 5,000	+48,000	+40,000	+32,000	+27,000	+24,000
	0	+51,000	+43,000	+36,000	+31,000	+27,000
	+ 5,000	+53,000	+46,000	+39,000	+34,000	+31,000
	+10,000	+55,000	+48,000	+42,000	+37,000	+35,000
	+15,000	+57,000	+51,000	+45,000	+41,000	+39,000
	+20,000	+58,000	+53,000	+48,000	+44,000	+42,000
14S-T6 alloy	−25,000	+37,000	+25,000	+16,000	+ 8,000	+ 5,000
	−20,000	+40,000	+30,000	+20,000	+13,000	+ 9,000
	−15,000	+43,000	+34,000	+24,000	+18,000	+14,000
	−10,000	+46,000	+37,000	+28,000	+22,000	+18,000
	− 5,000	+48,000	+40,000	+32,000	+26,000	+23,000
	0	+50,000	+42,000	+35,000	+30,000	+27,000
	+ 5,000	+52,000	+46,000	+39,000	+34,000	+31,000
	+10,000	+54,000	+48,000	+42,000	+38,000	+36,000
	+15,000	+56,000	+51,000	+46,000	+42,000	+40,000
	+20,000	+58,000	+53,000	+49,000	+46,000	+44,000
	+25,000	+60,000	+56,000	+52,000	+50,000	+48,000
	+30,000	+62,000	+58,000	+55,000	+53,000	+52,000
	+35,000	+63,000	+60,000	+58,000	+57,000	+55,000
52S-H36 alloy	−25,000	+19,000	+ 9,000	+ 6,000	+ 4,000	+ 3,000
	−20,000	+22,000	+14,000	+11,000	+10,000	+ 9,000
	−15,000	+26,000	+19,000	+17,000	+16,000	+15,000
	−10,000	+29,000	+24,000	+22,000	+21,000	+20,000
	− 5,000	+32,000	+28,000	+27,000	+26,000	+25,000
	0	+34,000	+32,000	+31,000	+30,000	+29,000
	+ 5,000	+36,000	+35,000	+34,000	+33,000	+32,000
61S-T6 alloy	−20,000	+29,000	+20,000	+12,000	+ 6,000	+ 3,000
	−15,000	+32,000	+24,000	+16,000	+10,000	+ 7,000
	−10,000	+34,000	+27,000	+20,000	+15,000	+12,000
	− 5,000	+36,000	+30,000	+24,000	+19,000	+17,000
	0	+38,000	+33,000	+28,000	+24,000	+22,000
	+ 5,000	+40,000	+35,000	+31,000	+28,000	+27,000

TABLE 7—TYPICAL TENSILE PROPERTIES OF SOME ALUMINUM ALLOYS AT ELEVATED TEMPERATURES

(Lowest Strengths During 10,000 Hours of Heating at Testing Temperature)

Alloy and Temper	Temp., °F	Tensile Strength, Lb./sq. in.	Yield Strength (Offset=0.2%), Lb./sq. in.	Elong. in 2 in., %
3S-O	75	16,000	6,000	40
	212	13,000	5,500	43
	300	11,000	5,000	47
	400	8,500	4,500	50
	500	6,000	3,500	60
	600	4,000	2,500	60
	700	3,000	2,000	60
3S-H14	75	21,500	19,000	16
	212	19,500	16,000	16
	300	17,500	12,500	17
	400	14,000	8,000	22
	500	10,000	4,000	25
	600	5,000	2,500	40
	700	3,000	2,000	60
3S-H18	75	29,000	26,000	10
	212	25,500	19,000	10
	300	22,500	14,500	12
	400	16,500	6,500	18
	500	10,000	4,000	25
	600	4,000	2,500	55
	700	3,000	2,000	60
4S-O	75	26,000	10,000	25
	212	26,000	10,000	30
	300	22,000	9,500	40
	400	15,000	8,000	65
	500	10,000	6,000	80
	600	6,500	3,500	90
	700	4,500	2,500	100
4S-H34	75	34,000	27,000	12
	212	33,000	24,000	12
	300	27,000	17,000	20
	400	20,000	8,500	38
	500	13,000	6,000	65
	600	7,000	3,500	90
	700	4,500	2,500	100
4S-H38	75	40,000	34,000	6
	212	38,000	31,000	7
	300	32,000	19,000	14
	400	22,000	8,000	35
	500	11,000	6,000	65
	600	6,500	3,500	90
	700	4,500	2,500	100
14S-T6	75	70,000	60,000	13
	212	62,000	56,000	18
	300	39,000	32,000	20
	400	17,000	12,000	40
	500	9,500	8,000	60
	600	6,500	5,500	65
	700	5,000	3,500	70
24S-T4[1]	75	68,000	48,000	19
	212	61,000	45,000	17
	300	43,000	37,000	17
	400	26,000	22,000	22
	500	14,000	10,000	45
	600	7,000	5,000	75
	700	5,000	3,500	100
52S-O	75	27,000	12,000	30
	212	26,000	11,000	40
	300	20,000	10,000	55
	400	15,000	9,000	65
	500	11,000	7,000	100
	600	7,500	4,500	105
	700	5,000	2,500	120
52S-H36	75	39,000	34,000	10
	212	37,000	32,000	12
	300	32,000	27,000	16
	400	24,000	11,000	35
	500	12,000	8,000	80
	600	8,000	4,500	100
	700	5,000	2,500	120
61S-T6	75	45,000	40,000	17
	212	41,000	37,000	18
	300	32,000	30,000	18
	400	19,000	16,000	25
	500	7,000	5,000	55
	600	4,000	2,500	85
	700	3,000	2,000	95
195-T4[1]	75	32,000	16,000	8.5
	300	24,000	13,000	9.0
	400	15,000	9,000	20.0
	500	9,500	6,000	25.0
	600	4,000	3,000	80.0
214	75	25,000	12,000	9.0
	300	23,000	12,000	7.0
	400	18,500	12,000	9.0
	500	13,500	8,000	12.0
	600	9,000	4,000	17.0
220-T4[1]	75	46,000	25,000	14.0
	300	38,000	19,000	15.0
	400	23,000	12,000	40.0
	500	15,000	7,000	50.0
	600	11,000	3,500	70.0
356-T6	75	33,000	24,000	4.0
	300	21,000	16,000	5.0
	400	13,000	9,000	8.0
	500	8,000	5,500	20.0
	600	4,500	3,000	45.0

[1]The resistance to corrosion of these alloys is usually adversely affected by exposure to elevated temperatures.

TABLE 8—APPROXIMATE THERMAL EXPANSION OF WROUGHT ALUMINUM ALLOYS

Temperature Range from −50°F. to +150°F.

Length in feet	Change in Length in inches									
	Temperature Change in Degrees Fahrenheit									
	10	20	30	40	50	60	70	80	90	100
10	0.015	0.030	0.045	0.060	0.075	0.090	0.105	0.120	0.135	0.150
20	0.030	0.060	0.090	0.120	0.150	0.180	0.210	0.240	0.270	0.300
30	0.045	0.090	0.135	0.180	0.225	0.270	0.315	0.360	0.405	0.450
40	0.060	0.120	0.180	0.240	0.300	0.360	0.420	0.480	0.540	0.600
50	0.075	0.150	0.225	0.300	0.375	0.450	0.525	0.600	0.675	0.750
60	0.090	0.180	0.270	0.360	0.450	0.540	0.630	0.720	0.810	0.900
70	0.105	0.210	0.315	0.420	0.525	0.630	0.735	0.840	0.945	1.050
80	0.120	0.240	0.360	0.480	0.600	0.720	0.840	0.960	1.080	1.200
90	0.135	0.270	0.405	0.540	0.675	0.810	0.945	1.080	1.215	1.350
100	0.150	0.300	0.450	0.600	0.750	0.900	1.050	1.200	1.350	1.500

Coefficient of thermal expansion per degree Fahrenheit taken as 0.0000125 for wrought aluminum alloys, which is approximately 1.9 times value for medium structural steel.

TABLE 9—APPROXIMATE RADII FOR 90° COLD BENDS OF ALUMINUM ALLOY SHEET

Minimum permissible radius[1] varies with nature of forming operation, type of forming equipment, and design and condition of tools. Minimum working radius for given material or hardest alloy and temper for a given radius can be ascertained only by actual trial under contemplated conditions of fabrication.

Alloy	Bend classification[2]	Alloy	Bend classification[2]
3S-O	A	24S-O[4]	B
3S-H12	B	24S-T4[3,4]	J
3S-H14	C		
3S-H16	E	52S-O	B
3S-H18	G	52S-H32	C
		52S-H34	D
4S-O	B	52S-H36	F
4S-H32	C	52S-H38	G
4S-H34	D		
4S-H36	F	61S-O	B
4S-H38	G	61S-T4[3]	E
		61S-T6	F
14S-O[4]	B		
14S-T4[4]	H		
14S-T6[4]	K		

[1]See page 14.

[2]For corresponding bend radii see table below.

[3]Immediately after quenching, these alloys can be formed over appreciably smaller radii.

[4]Alclad 14S and 24S can be bent over slightly smaller radii than the corresponding tempers of the nonclad alloy.

RADII REQUIRED FOR 90° BEND IN TERMS OF THICKNESS, t

	Approximate Thickness					
B & S Gage	26	20	14	8	5	2
Inch	0.016	0.032	0.064	0.128	0.189	0.258
Inch	1/64	1/32	1/16	1/8	3/16	1/4
Bend Classification A	0	0	0	0	0	0
B	0	0	0	0	0–1t	0–1t
C	0	0	0	0–1t	0–1t	½t–1½t
D	0	0	0–1t	½t–1½t	1t–2t	1½t–3t
E	0–1t	0–1t	½t–1½t	1t–2t	1½t–3t	2t–4t
F	0–1t	½t–1½t	1t–2t	1½t–3t	2t–4t	2t–4t
G	½t–1½t	1t–2t	1½t–3t	2t–4t	3t–5t	4t–6t
H	1t–2t	1½t–3t	2t–4t	3t–5t	4t–6t	4t–6t
J	1½t–3t	2t–4t	3t–5t	4t–6t	4t–6t	5t–7t
K	2t–4t	3t–5t	3t–5t	4t–6t	5t–7t	6t–10t

DESIGN OF

ALUMINUM ALLOY STRUCTURES

THE SELECTION OF ALLOWABLE WORKING STRESSES

IN STRUCTURAL DESIGN, it is common practice to compute the stresses to which the various parts of a structure will probably be subjected during its life. The shape and size of the various parts of the structure are adjusted so that these computed stresses do not exceed certain limiting values called allowable working stresses. These allowable working stresses, then, become the basis for proportioning most of the parts of a structure.

The selection of allowable working stresses for structural materials is a matter of prime importance to the designer, because these stresses must provide a suitable margin of safety against failure of the structure. Obviously, an allowable stress for one structural application of a given material may be too conservative for another application. Since structural aluminum is used in a great variety of ways, no attempt is made in this book to recommend definite allowable working stresses for the various alloys. Instead, data are presented to show the strength of members made from the various wrought alloys in tension, compression, buckling, shear, bearing and fatigue. This information, which is based on both theoretical and laboratory studies, should provide the engineer with the essential information necessary for an intelligent selection of allowable working stresses in any given structure.

Factor of Safety

The allowable working stresses in any material for any condition of loading are generally selected as high as may be consistent with the strength of the material for that condition of loading. The ratio of the strength of the material to the allowable working stress is usually called the factor of safety.

A given allowable working stress in tension presents one factor of safety with respect to yield strength and a quite different factor of safety with respect to ultimate strength. Similarly, a given allowable stress for compression or shear may present one factor of safety against buckling and a higher factor of safety against ultimate failure. For these reasons, it is obviously impossible to obtain the same factor of safety throughout a set of allowable working stresses for any given material. In fact, a uniform factor of safety would probably not be desirable even if it could be attained. For

example, in many applications, the factor of safety against buckling of plate girder webs can be permitted to be smaller than that against tensile fracture of the material, and in such instances the use of the same factor of safety would result in uneconomical design.

In selecting suitable allowable working stresses for aluminum alloys for various structural applications, the following factors will be found important:

(a) *The precision with which the assumed loadings represent the actual service loadings, both present and future.* When there is much uncertainty about actual loadings, allowable working stresses should be selected more conservatively than in cases where loadings are known with considerable accuracy. On the other hand, if the uncertainty surrounding the actual loading leads to the adoption of very heavy assumed loadings, then part of the factor of safety is already included in these loadings and it would be wasteful of material to repeat this factor of safety by using very low allowable working stresses. Where moving loads are encountered, the selection of a suitable impact factor to represent the dynamic effects is highly important.

(b) *The precision with which the stresses in the structure are calculated.* Allowable working stresses should always be conservatively selected if in the design calculations the stresses are determined by methods which are known to give only approximate results. Refinements in calculations of stresses, if carried out consistently, should permit the use of higher allowable working stresses. For example, in the design of a riveted truss, allowable working stresses should be higher if both the primary and secondary stresses are calculated than if only the primary stresses are calculated.

(c) *The importance of the structure being designed.* In designing important major structures in which failures might cause considerable property damage and even loss of life, the allowable working stresses are selected more conservatively than would be the case in less important structures in which the consequences of failure would be less severe. Similarly, some members or parts of members may be more important than others, and it may be desirable to adjust the factor of safety accordingly.

Tension

In selecting an allowable stress suitable for the net section of tension members, the most important mechanical property of the material is the tensile yield strength, which is given in Table 3,

page 23, for the various wrought Alcoa Aluminum Alloys. There is no sudden yielding in the aluminum alloys, and therefore, the yield strength is defined as the stress at which the permanent set is 0.2 per cent of the original gage length. When a stress of this magnitude is first applied, a permanent elongation of about 1/64 inch for each 8 inches of length will occur. Since permanent elongations of even this small amount are considered undesirable, the allowable tensile working stresses for aluminum alloys are usually established by dividing the yield strength by a factor of safety suitable to the conditions of the problem in hand. In selecting tensile working stresses, some engineers use the typical yield strength of the material (Table 3), and others use the guaranteed minimum value (Tables 35 to 39). The factor of safety will, of course, be influenced by this choice.

The spread between yield strength and tensile strength in the aluminum alloys is large enough to provide a considerable extra factor of safety against tensile fracture. Some engineers determine the allowable tensile working stress separately for yield and ultimate and use the lower of the two values, the factor of safety in the case of the ultimate being larger than that used in the case of the yield by some arbitrary amount. For example, in some fields of design a factor of safety of 2 on the yield strength, or 3 on the ultimate strength is used. These are matters concerning which no fixed rules can be made; the engineer must rely on his own judgment and experience.

Compression

The structural Alcoa Aluminum Alloys, in common with other ductile materials, do not possess a definite ultimate compressive strength. When short, compact specimens of aluminum alloys are highly stressed in compression, the material flows out laterally so that the increased area continues to support the increasing load. Therefore, in Table 3 no compressive ultimate strength is given.

In Table 3 it will be noted that the compressive yield strengths of the various alloys are equal to the tensile yield strengths. Therefore, it is usually satisfactory to select an allowable working stress in compression equal to that selected in tension. This basic allowable compressive working stress applies only to short, compact members, the longer, less compact members being designed according to the column formula or other buckling formulas discussed on the following pages.

Columns

The column strength of aluminum alloys, as with other metals, is a function not only of the properties of the material but also of the slenderness ratio of the member. Table 10, page 37, gives the column formulas for the various Alcoa Alloys. Using these formulas, the ultimate strength curve for axially loaded columns of any given alloy can be constructed readily.

It will be noted in Table 10 that the column formulas are expressed in terms of $\frac{KL}{r}$, which is called "effective slenderness ratio." The factor K represents the effect of the end conditions of the member, the following being some of the values of this factor:

For both ends completely fixed	$K=0.5$
For one end fixed and one end pinned	$K=0.7$
For both ends pinned	$K=1.0$
For one end fixed and one end free (cantilever compression member)	$K=2.0$

The designer can select a value of K corresponding to any given set of end conditions which may be encountered. In making his selection the designer may find it helpful to think of KL as the portion of the member which functions as if it were pin-ended, that is, the length between points of contraflexure when the member is in its deflected position. This deflected position should be visualized in terms of the conditions which would exist just before failure.

Most compression members in modern framed structures have partially fixed ends so that a K value should be selected somewhere between fixed and pinned. Since few compression members are completely fixed, the value of K should rarely be selected less than 0.6. In fact, a study of the behavior of compression members in framed structures indicates that many of such members are more nearly pinned than fixed, so that values of K less than 0.75 are to be regarded with suspicion unless restricted to slender members rigidly connected at both ends to members relatively much stiffer.

Table 11, page 38, gives values of ultimate column strength corresponding to various effective slenderness ratios for the wrought Alcoa Aluminum Alloys.

In selecting allowable working stresses for aluminum alloy columns, it is necessary to divide the ultimate column strengths referred to above by a suitable factor of safety. The factor of safety selected should be at least as conservative as that used with the tensile yield strength in selecting the basic tensile and compressive working stresses.

(Continued on page 40)

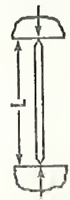
TABLE 10—ULTIMATE STRENGTH FORMULAS FOR AXIALLY LOADED ALUMINUM ALLOY COLUMNS

Representative of material having the typical properties shown in Table 3

K=0.5

Members are assumed to be compact enough so that no local failure will occur.

$\frac{P}{A}$ = ultimate strength of column in lb./sq. in.
L = unsupported length of column in inches
r = corresponding radius of gyration in inches
K = 0.5 for both ends fixed
K = 1.0 for both ends hinged



K=1.0

Alloy	Typical Compressive Yield Strength Lb./sq. in.	For $\frac{KL}{r}$ less than C	C	For $\frac{KL}{r}$ greater than C
3S-O	6,000	$\frac{P}{A}= 6{,}200- 18\frac{KL}{r}$	194	$\frac{P}{A}=\frac{102{,}000{,}000}{\left(\frac{KL}{r}\right)^2}$
3S-H12	17,000	$\frac{P}{A}=18{,}400- 95\frac{KL}{r}$	126	
3S-H14	19,000	$\frac{P}{A}=20{,}800-114\frac{KL}{r}$	116	"
3S-H16	22,000	$\frac{P}{A}=24{,}400-145\frac{KL}{r}$	108	"
3S-H18	26,000	$\frac{P}{A}=29{,}400-192\frac{KL}{r}$	100	"
4S-O	10,000	$\frac{P}{A}=10{,}500- 41\frac{KL}{r}$	170	"
4S-H32	22,000	$\frac{P}{A}=24{,}400-145\frac{KL}{r}$	108	"
4S-H34	27,000	$\frac{P}{A}=30{,}600-204\frac{KL}{r}$	100	"
4S-H36	31,000	$\frac{P}{A}=35{,}800-258\frac{KL}{r}$	91	"
4S-H38	34,000	$\frac{P}{A}=39{,}800-302\frac{KL}{r}$	85	"
14S-T4	41,000	$\frac{P}{A}=49{,}400-418\frac{KL}{r}$	77	"
14S-T6	60,000	$\frac{P}{A}=78{,}000-830\frac{KL}{r}$	63	"
24S-T4	48,000	$\frac{P}{A}=59{,}500-553\frac{KL}{r}$	71	"
52S-O	12,000	$\frac{P}{A}=12{,}700- 54\frac{KL}{r}$	144	"
52S-H32	27,000	$\frac{P}{A}=30{,}600-204\frac{KL}{r}$	100	"
52S-H34	31,000	$\frac{P}{A}=35{,}800-258\frac{KL}{r}$	91	"
52S-H36	34,000	$\frac{P}{A}=39{,}800-302\frac{KL}{r}$	85	"
52S-H38	36,000	$\frac{P}{A}=42{,}500-334\frac{KL}{r}$	84	"
61S-T4	21,000	$\frac{P}{A}=23{,}200-134\frac{KL}{r}$	109	"
61S-T6	40,000	$\frac{P}{A}=48{,}000-400\frac{KL}{r}$	77	"

TABLE 11—VALUES OF ULTIMATE COLUMN STRENGTH CORRESPONDING TO FORMULAS IN TABLE 10

$\frac{KL}{r}$	3S-O	3S-H12	3S-H14	3S-H16	3S-H18	4S-O	4S-H32	4S-H34	4S-H36	4S-H38
0	*6,200*	*18,400*	*20,800*	*24,400*	*29,400*	*10,500*	*24,400*	*30,600*	*35,800*	*39,800*
5	*6,110*	*17,930*	*20,230*	*23,680*	*28,440*	*10,300*	*23,680*	*29,580*	*34,510*	*38,290*
10	*6,020*	*17,450*	*19,660*	*22,950*	*27,480*	*10,090*	*22,950*	*28,560*	*33,220*	*36,780*
15	5,930	16,980	*19,090*	*22,230*	*26,520*	9,890	*22,230*	*27,540*	*31,930*	*35,270*
20	5,840	16,500	18,520	21,500	25,560	9,680	21,500	26,520	30,640	33,760
25	5,750	16,030	17,950	20,780	24,600	9,480	20,780	25,500	29,350	32,250
30	5,660	15,550	17,380	20,050	23,640	9,270	20,050	24,480	28,060	30,740
35	5,570	15,080	16,810	19,330	22,680	9,070	19,330	23,460	26,770	29,230
40	5,480	14,600	16,240	18,600	21,720	8,860	18,600	22,440	25,480	27,720
45	5,390	14,130	15,670	17,880	20,760	8,660	17,880	21,420	24,190	26,210
50	5,300	13,650	15,100	17,150	19,800	8,450	17,150	20,400	22,900	24,700
55	5,210	13,180	14,530	16,430	18,840	8,250	16,430	19,380	21,610	23,190
60	5,120	12,700	13,960	15,700	17,880	8,040	15,700	18,360	20,320	21,680
65	5,030	12,230	13,390	14,980	16,920	7,840	14,980	17,340	19,030	20,170
70	4,940	11,750	12,820	14,250	15,960	7,630	14,250	16,320	17,740	18,660
75	4,850	11,280	12,250	13,530	15,000	7,430	13,530	15,300	16,450	17,150
80	4,760	10,800	11,680	12,800	14,040	7,220	12,800	14,280	15,160	15,640
85	4,670	10,330	11,110	12,080	13,080	7,020	12,080	13,260	13,870	14,120
90	4,580	9,850	10,540	11,350	12,120	6,810	11,350	12,240	12,580	12,590
95	4,490	9,380	9,970	10,630	11,160	6,610	10,630	11,220	11,300	11,300
100	4,400	8,900	9,400	9,900	10,200	6,400	9,900	10,200	10,200	10,200
120	4,040	7,000	7,080	7,080	7,080	5,580	7,080	7,080	7,080	7,080
140	3,680	5,200	5,200	5,200	5,200	4,760	5,200	5,200	5,200	5,200
160	3,320	3,980	3,980	3,980	3,980	3,940	3,980	3,980	3,980	3,980
180	2,960	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
200	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550
220	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110
240	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770
260	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510
280	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300

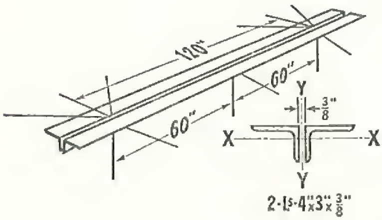
Concluded on opposite page.

TABLE 11—VALUES OF ULTIMATE COLUMN STRENGTH CORRESPONDING TO FORMULAS IN TABLE 10—Concluded

$\frac{KL}{r}$	14S-T4	14S-T6	24S-T4	52S-O	52S-H32	52S-H34	52S-H36	52S-H38	61S-T4	61S-T6
0	*49,400*	*78,000*	*59,500*	*12,700*	*30,600*	*35,800*	*39,800*	*42,500*	*23,200*	*48,000*
5	*47,310*	*73,850*	*56,740*	*12,430*	*29,580*	*34,510*	*38,290*	*40,830*	*22,530*	*46,000*
10	*45,220*	*69,700*	*53,970*	*12,160*	*28,560*	*33,220*	*36,780*	*39,160*	*21,860*	*44,000*
15	*43,130*	*65,550*	*51,210*	11,890	*27,540*	*31,930*	*35,270*	*37,490*	*21,190*	*42,000*
20	*41,040*	*61,400*	*48,440*	11,620	26,520	30,640	33,760	35,820	20,520	40,000
25	38,950	57,250	45,680	11,350	25,500	29,350	32,250	34,150	19,850	38,000
30	36,860	53,100	42,910	11,080	24,480	28,060	30,740	32,480	19,180	36,000
35	34,770	48,950	40,150	10,810	23,460	26,770	29,230	30,810	18,510	34,000
40	32,680	44,800	37,380	10,540	22,440	25,480	27,720	29,140	17,840	32,000
45	30,590	40,650	34,620	10,270	21,420	24,190	26,210	27,470	17,170	30,000
50	28,500	36,500	31,850	10,000	20,400	22,900	24,700	25,800	16,500	28,000
55	26,410	32,350	29,090	9,730	19,380	21,610	23,190	24,130	15,830	26,000
60	24,320	28,200	26,320	9,460	18,360	20,320	21,680	22,460	15,160	24,000
65	22,230	24,140	23,560	9,190	17,340	19,030	20,170	20,790	14,490	22,000
70	20,140	20,820	20,790	8,920	16,320	17,740	18,660	19,120	13,820	20,000
75	18,050	18,130	18,130	8,650	15,300	16,450	17,150	17,450	13,150	18,000
80	15,940	15,940	15,940	8,380	14,280	15,160	15,640	15,780	12,480	15,940
85	14,120	14,120	14,120	8,110	13,260	13,870	14,120	14,120	11,810	14,120
90	12,590	12,590	12,590	7,840	12,240	12,580	12,590	12,590	11,140	12,590
95	11,300	11,300	11,300	7,570	11,220	11,300	11,300	11,300	10,470	11,300
100	10,200	10,200	10,200	7,300	10,200	10,200	10,200	10,200	9,800	10,200
120	7,080	7,080	7,080	6,220	7,080	7,080	7,080	7,080	7,080	7,080
140	5,200	5,200	5,200	5,140	5,200	5,200	5,200	5,200	5,200	5,200
160	3,980	3,980	3,980	3,980	3,980	3,980	3,980	3,980	3,980	3,980
180	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150	3,150
200	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550	2,550
220	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110	2,110
240	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770	1,770
260	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510	1,510
280	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300	1,300

Values in italic type are above the compressive yield strength of the material.

Example 1. Design the compression chord of a truss for an axial load of 47,000 lb., using a factor of safety of 2.5.



Try two angles $4'' \times 3'' \times \frac{3}{8}''$, 61S-T6 alloy, area = 4.98 sq. in.

Calculated stress $= \frac{P}{A} = \frac{47,000}{4.98}$
= 9440 lb./sq. in.

Axis X,
$L = 60''$, $r = 0.86$, assume $K = 0.8$.
$\frac{KL}{r} = \frac{0.8 \times 60}{0.86} = 56.$

Axis Y,
$L = 120''$, $r = 1.91$, assume $K = 0.8$.
$\frac{KL}{r} = \frac{0.8 \times 120}{1.91} = 50.$

Greatest value of $\frac{KL}{r}$ is 56, about Axis X.

Ultimate column strength (Table 10, 61S-T6 alloy) $= 48,000 - 400 \times 56$
$= 25,600$ lb./sq. in.

Allowable working stress (factor of safety of 2.5) $= \frac{25,600}{2.5}$
$= 10,240$ lb./sq. in.

Since this allowable stress is greater than the calculated stress of 9440 lb./sq. in., the member selected is satisfactory.

In the foregoing discussion of column strength, it is assumed that members are compact enough so that no local buckling failures will occur. When columns are made up of thin sections, failures sometimes occur by local buckling at stresses below those indicated by the column formulas. In order to design such members safely and economically, it is necessary to check the allowable compressive working stress not only from the column formula, but also from local buckling formulas, the final allowable working stress for the member being the lower of the values arrived at in this manner. Local buckling formulas are discussed in the following paragraphs.

Local Buckling of Flat Plates Under Edge Compression

When a flat plate is used as a component part of a column or other compression member, it may buckle locally under edge compression at stresses below the compressive yield strength of the material. Buckling occurs in the form of local waves or wrinkles

which are practically independent of the length of the member. These local buckling failures in plates may be treated conveniently as local column failures, using the ordinary column formula for the material, provided the proper equivalent slenderness ratio is used. A list of these equivalent slenderness ratios for various conditions of edge support is given below in terms of "b," the unsupported width of the plate, and "t," the thickness of the plate, both in inches.

1. Both edges simply supported (e.g., the web of an H-beam with relatively thin flanges).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 1.65\frac{b}{t}.$$

2. Both edges built in (e.g., the web of an H-beam with relatively thick flanges).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 1.25\frac{b}{t}.$$

3. One edge simply supported, other edge free (e.g., longest outstanding leg of a single angle strut).

$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 5.1\frac{b}{t}.$$

4. One edge built in, other edge free (e.g., the outstanding leg of an angle with other leg riveted to thicker members).

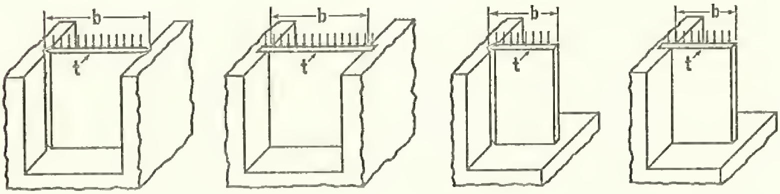
$$\text{Equivalent slenderness ratio } \frac{KL}{r} = 2.9\frac{b}{t}.$$

The above values of equivalent slenderness ratio, $\frac{KL}{r}$, may be substituted directly in the ultimate column strength formulas for the various aluminum alloys to determine the critical stresses at which flat plates under edge compression will begin to buckle noticeably. In using these values it should be remembered that they are based on theoretical conditions of edge restraint. In actual structural design, it is necessary, of course, to select constants intermediate between fixed and simply supported conditions, depending on the actual conditions of the member being designed. Table 12 gives values of equivalent slenderness ratio for flat plates under edge compression.

The factors of safety to be used with the foregoing critical buckling stresses will depend largely on the type of structure being designed. Generally, it is not necessary to provide as large a factor of safety against flat plate buckling as against tensile fracture or column failure, because many compression members incorporating flat

TABLE 12—VALUES OF EQUIVALENT SLENDERNESS RATIO, $\frac{KL}{r}$, FOR FLAT PLATES SUBJECTED TO EDGE COMPRESSION

$$\frac{b}{t} = \frac{\text{unsupported width of plate}}{\text{thickness of plate}}$$

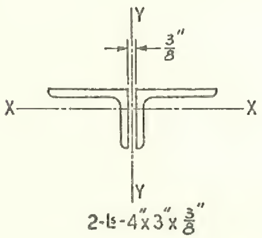


Both edges simply supported $\frac{KL}{r} = 1.65\frac{b}{t}$				Both edges built in $\frac{KL}{r} = 1.25\frac{b}{t}$				One edge simply supported, other edge free $\frac{KL}{r} = 5.1\frac{b}{t}$		One edge built in, other edge free $\frac{KL}{r} = 2.9\frac{b}{t}$	
$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$	$\frac{b}{t}$	$\frac{KL}{r}$
2	3	32	53	2	3	32	40	2	10	2	6
4	7	34	56	4	5	34	43	4	20	4	12
6	10	36	59	6	8	36	45	6	31	6	17
8	13	38	63	8	10	38	48	8	41	8	23
10	17	40	66	10	13	40	50	10	51	10	29
12	20	45	74	12	15	45	56	12	61	12	35
14	23	50	83	14	18	50	63	14	71	14	41
16	26	55	91	16	20	55	69	16	82	16	46
18	30	60	99	18	23	60	75	18	92	18	52
20	33	65	107	20	25	65	81	20	102	20	58
22	36	70	116	22	28	70	88	22	112	22	64
24	40	75	124	24	30	75	94	24	122	24	70
26	43	80	132	26	33	80	100	26	133	26	75
28	46	90	149	28	35	90	113	28	143	28	81
30	50	100	165	30	38	100	125	30	153	30	87

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10, page 37) to determine the critical compressive stresses at which plates of various aluminum alloys will buckle.

plates are capable of carrying considerable load beyond that at which buckling begins. Quite often appearance is the controlling factor in the selection of the factor of safety to be used with the critical buckling stresses.

Example 2. Check member used in Example 1, page 40, to see if buckling of outstanding leg controls the design.



$\frac{b}{t}$ for 4″ leg $= \frac{4.00-0.375}{0.375} = 9.7$

The equivalent slenderness ratio for this member is between the following (page 41):

$5.1\frac{b}{t}$ (one edge simply supported, other edge free)

$2.9\frac{b}{t}$ (one edge built in, other edge free)

This member is nearer the first condition, the edge of the 4″ leg being restrained only by the 3″ leg plus what little restraint comes from the stitch rivets used to hold the two angles together.

Assume equivalent slenderness ratio $= 4.5\,\frac{b}{t} = 4.5 \times 9.7 = 44.$

This value is less than the effective slenderness ratio of the member as a whole, 56, so the member will have a greater factor of safety against local buckling than against column action, therefore local buckling does not control the design.

Example 2a. Check member in Example 1 to see if local buckling would have controlled design if the length of member between panel points had been 32″ instead of 60″.

For L = 32″, the effective slenderness ratio of the member would have been $\frac{0.8 \times 32}{0.86} = 30.$

The equivalent slenderness ratio of the 4″ outstanding leg, however, would not be changed from the value, 44, arrived at in Example 2.

Since this value is now greater than the effective slenderness ratio of the whole member, local buckling controls the design.

The critical buckling stress for this member is found by substituting the equivalent slenderness ratio, 44, in the column formula for 61S-T6 alloy (Table 10, 61S-T6).

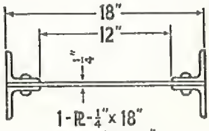
Critical stress $= 48{,}000 - 400 \times 44 = 30{,}400$ lb./sq. in.

Allowable working stress (factor of safety of 2.5)

$= \frac{30{,}400}{2.5} = 12{,}160$ lb./sq. in.

This allowable stress is so much larger than the calculated stress, 9440 lb./sq. in. (Example 1), that a smaller member might well be used.

Example 3. Check the 61S-T6 member shown in the sketch to determine the factor of safety against buckling of the flat plate when the member is subjected to an axial load of 200,000 lb.



1-PL-$\frac{1}{4}$"x 18"
4-Ls-3"x3"x$\frac{1}{2}$"
Area = 15.46 sq.in.

Calculated compressive stress

$$=\frac{P}{A}=\frac{200{,}000}{15.46}=12{,}900 \text{ lb./sq. in.}$$

The equivalent slenderness ratio of the flat plate will lie between the values $1.65\,\frac{b}{t}$ and $1.25\,\frac{b}{t}$ (edges simply supported and edges fixed, page 41).

$$\text{Assume equivalent slenderness ratio} = 1.35\,\frac{b}{t} = 1.35\,\frac{12}{0.25} = 65.$$

$$\text{Critical stress (Table 10, 61S-T6 alloy)} = 48{,}000 - 400 \times 65$$
$$= 22{,}000 \text{ lb./sq. in.}$$

$$\text{Factor of safety against buckling of the plate} = \frac{22{,}000}{12{,}900} = 1.71.$$

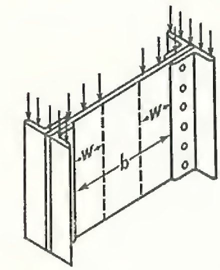
In designing members in which both edges of a flat plate are built into members which will not fail at stresses below the yield strength of the material and in which there is no problem of appearance, engineers sometimes disregard buckling of the flat plate altogether and design the member, using only a portion of the plate area along the built-in edges as being effective. The center portion of the plate is assumed to have no load-carrying capacity. In such cases the width of plate which may be considered effective along each edge may be found by means of the following formula:

$$\text{Effective width of plate} = \frac{2700}{\sqrt{YS}}\,t,$$

where t = thickness of plate in inches,
YS = yield strength of material in lb./sq. in.

Table 13, page 45, gives values of effective width of plate for the various wrought Alcoa Aluminum Alloys based on the typical yield strengths given in Table 3. In using these effective widths it should be remembered that they must never exceed one-half the clear width of the plate between the built-in edges; that is, they must never overlap at the center of the clear width.

TABLE 13—EFFECTIVE WIDTHS OF FLAT PLATES IN EDGE COMPRESSION



Effective width of plate along each edge which may be considered acting with the flange in resisting ultimate compression failure, the center portion of the plate assumed to have buckled.

$$W = \frac{2700}{\sqrt{\text{yield strength}}}\,t$$

where t = thickness of plate in inches.

Note.—Effective width, W, must never be taken greater than $\frac{b}{2}$.

Alloy	W	Alloy	W	Alloy	W	Alloy	W
3S-H12	20.7t	4S-H32	18.2t	52S-H32	16.4t	61S-T4	18.6t
3S-H14	19.6t	4S-H34	16.4t	52S-H34	15.3t	61S-T6	13.5t
3S-H16	18.2t	4S-H36	15.3t	52S-H36	14.6t		
3S-H18	16.7t	4S-H38	14.6t	52S-H38	14.2t		
14S-T4	13.3t	14S-T6	11.0t	24S-T4	12.3t		

Example 4. Check the 61S-T6 member used in Example 3 to determine factor of safety against compression failure, failure assumed to occur at the yield strength of the material (40,000 lb./sq. in.).

Effective width of plate along each edge (Table 13)
$= 13.5t = 13.5 \times 0.25 = 3.38''$.

Total effective area of plate $= 2 \times (3.38 + 3) \times 0.25 =$ 3.19 sq. in.
Area of angles $=$ 10.96 sq. in.
Total effective area of member, A_e, $=$ 14.15 sq. in.

$$\text{Calculated compressive stress} = \frac{P}{A_e} = \frac{200{,}000}{14.15} = 14{,}130 \text{ lb./sq. in.}$$

$$\text{Factor of safety against failure} = \frac{40{,}000}{14{,}130} = 2.8.$$

Note.—If 14S-T6 alloy had been used instead of 61S-T6, the effective width would have been less ($11.0t = 2.75''$), but the factor of safety against failure would have been greater ($60{,}000/14{,}460 = 4.2$).

Local Buckling of Curved Plates Under Edge Compression

Curved plates are better suited for resisting local buckling failures under edge compression than are flat plates, and consequently the critical stresses are generally higher for a given thickness. These critical stresses may be determined in the same manner as for flat plates, however, by using the following value of equivalent slenderness ratio, expressed in terms of the radius of curvature, R, and the wall thickness, t, both in inches:

$$\text{Equivalent slenderness ratio (Curved Plates)} = 5.7\sqrt{\frac{R}{t}}$$

The above value of equivalent slenderness ratio applies to curved plates used to form complete tubular members. The same value may be used for curved plates, forming less than complete cylinders, provided the edges are adequately stiffened so that failure will not occur by buckling of a free edge.

Seamless aluminum alloy tubes are considerably stronger in resisting local wall buckling than are curved plates of the same radius and thickness in built-up construction, and for this reason the equivalent slenderness ratio for seamless tubes should be lower than that for curved plates. The following value of equivalent slenderness ratio may be used for seamless tubes:

$$\text{Equivalent slenderness ratio (Seamless Tubes)} = 4.7\sqrt{\frac{R}{t}}$$

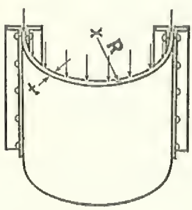
The above values of the equivalent slenderness ratio may be substituted directly in the ultimate column strength formulas for the various aluminum alloys (Table 10) to determine the critical stresses at which curved plates under edge compression will begin to buckle noticeably. The factor of safety to be used with these critical buckling stresses should be about as conservative as that used to determine the allowable working stresses in columns, because buckling of curved plates in compression often results in complete failure of the member. This is particularly true if there are relatively few longitudinal stiffeners used on the curved plate.

Longitudinal stiffeners improve the buckling resistance of curved plates under edge compression, provided they are spaced closer together along the surface of the plate than a distance equal to the radius of curvature. No satisfactory general formulas have been devised for calculating the improvement in buckling resistance produced by various stiffener spacings on curved sheets. For the larger values of $\frac{R}{t}$ with close stiffener spacings, it is sometimes helpful to

calculate the buckling resistance of the sheet between stiffeners as though the sheet were flat (Table 12, page 42), knowing that the actual critical stress is somewhat higher than this value because of the stiffening effect of the curvature.

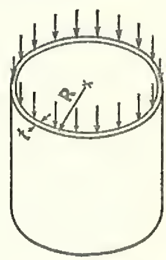
Table 14, below, shows the equivalent slenderness ratios for unstiffened curved plates in edge compression calculated in accordance with the foregoing information.

TABLE 14—VALUES OF EQUIVALENT SLENDERNESS RATIO, $\frac{KL}{r}$, FOR CURVED PLATES AND SEAMLESS TUBES



Curved Plates

$\frac{KL}{r} = 5.7\sqrt{\frac{R}{t}}$



Seamless Tubes

$\frac{KL}{r} = 4.7\sqrt{\frac{R}{t}}$

$\frac{R}{t} = \frac{\text{radius of curvature}}{\text{thickness of shell}}$

Curved plates						Seamless tubes	
$\frac{R}{t}$	$\frac{KL}{r}$	$\frac{R}{t}$	$\frac{KL}{r}$	$\frac{R}{t}$	$\frac{KL}{r}$	$\frac{R}{t}$	$\frac{KL}{r}$
10	18	120	62	500	127	10	15
20	25	140	67	550	134	20	21
30	31	160	72	600	140	30	26
40	36	180	76	650	145	40	30
50	40	200	81	700	151	50	33
60	44	250	90	750	156	60	36
70	48	300	99	800	161	70	39
80	51	350	107	850	166	80	42
90	54	400	114	900	171	90	45
100	57	450	121	1000	180	100	47

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which plates and tubes of various aluminum alloys will buckle.

Bending

In designing beams, girders and other flexural members, the allowable working stress in tension, to be used for the *net* area of the tension flange, should be the same as the basic allowable tensile stress used for tension members. The basic allowable compressive working stress used for the *gross* area of the compression flange should be the same as the basic allowable compressive working stress used for other compression members. This basic compressive stress, however, can be used only when the laterally unsupported length of the flange is relatively short. The allowable compressive working stress on compression flanges which are supported at longer intervals must be reduced so that a suitable factor of safety is provided against the possibility of a sidewise buckling failure. Such failures occur in compression flanges of beams in much the same manner that column failures occur in members subjected to direct compression. The stress at which such failures occur in a beam flange may be predicted by calculating the column strength of the flange, providing the equivalent radius of gyration of the compression flange is determined in accordance with the following formula:

$$\text{Equivalent radius of gyration of compression flange} = \sqrt{\frac{0.2}{S_c}\sqrt{I_1\left[J(KL)^2 + 13.1\, I_F d^2\right]}},$$

where S_c = section modulus for beam about axis normal to web (compression side) in inches^3

I_1 = moment of inertia for beam about principal axis parallel to web in inches^4

L = laterally unsupported length of compression flange in inches

K = factor representing end conditions of laterally unsupported length, same as for columns

I_F = moment of inertia of compression flange of beam about axis parallel to web (may be assumed equal to ½ of I_1 in the case of I-shaped members having both flanges alike) in inches^4

d = depth of beam in inches

J = torsion factor in inches^4.

The value of J for structural shapes is included in the tables of elements of sections in this handbook. A reasonably close approximation may readily be obtained for other single-web members by assuming the cross section of the member to be broken into a series

of rectangles. The value of J for the entire member is simply the sum of the individual torsion factors for the separate rectangles as follows:

$$J = \Sigma \tfrac{1}{3}\, bt^3,$$

where b is the length of each rectangle and t the thickness, both in inches. In the case of a girder built up of a web plate and four angles, the value for the angles may be taken from the tables and added to that for the plate determined as above.

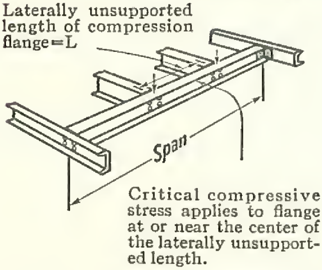
The value of equivalent radius of gyration (page 48) is used with KL, the effective unsupported length of the compression flange, to determine the effective slenderness ratio. This slenderness ratio is then substituted in the column formula for the alloy in question (Table 10, page 37) to arrive at the value of critical stress for the compression flange. This critical stress on the compression flange applies to the conditions which exist at or near the center of the unsupported length. Table 15, page 50, gives values of effective slenderness ratio for the various Alcoa Aluminum Alloy I-beams, H-beams and channels.

The equivalent radius of gyration determined according to the foregoing formula is usually greater than the radius of gyration which would be determined for the compression flange in the ordinary manner. Therefore, in most cases, the use of this formula results in higher values of critical compressive stress for beam flanges than would be obtained by considering the flange as a column, using the ordinary radius of gyration. In the case of compact beams, such as I-beams, the difference is often found to be very large so that the use of the more exact method leads to considerable economy of material. In the case of less compact members, such as built-up plate girders, the difference is usually less, and often the radius of gyration of such members, determined in the ordinary manner, comes very close to the value given by the formula on page 48.

The foregoing discussion of lateral stability of beams applies principally to I-shaped members. The method may be extended without serious error, however, to include channel-shaped members. In all cases it is assumed that the members are adequately supported against tipping or twisting at the point of application of the important loads and reactions. Where such support is not provided, the member should be checked to make sure that any eccentricity of the loads and reactions is taken into account in the calculation of stress. This is particularly true in the case of channel-shaped mem-

(Continued on page 52)

TABLE 15—VALUES OF EQUIVALENT SLENDERNESS RATIO FOR COMPRESSION FLANGES OF BEAMS



Equivalent slenderness ratio $= \frac{KL}{r}$

L = laterally unsupported length of compression flange in inches

K = factor representing end conditions of laterally unsupported length, same as for columns

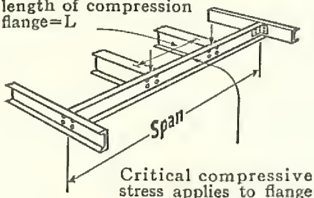
r = equivalent radius of gyration of compression flange defined on page 48

I-beams		Equivalent slenderness ratio of compression flange, $\frac{KL}{r}$, for various values of effective unsupported length						
Depth Inches	Weight Lb./ft.	KL = 24 inches	KL = 48 inches	KL = 96 inches	KL = 144 inches	KL = 192 inches	KL = 264 inches	KL = 360 inches
2	0.804	37.8	63.4	96.2	119.7	139.0	163.6	.....
2	1.473	30.5	46.4	67.0	82.4	95.3	111.9	130.7
2½	1.850	27.8	40.8	58.3	71.5	82.7	97.0	113.2
3	2.02	31.3	50.0	73.7	91.0	105.4	123.9	144.8
3	2.67	27.9	43.0	62.6	77.1	89.2	104.7	122.3
4	2.72	30.1	50.3	76.2	94.7	110.0	129.4	151.3
4	3.74	27.1	43.4	64.1	79.3	91.8	107.9	126.1
5	3.53	28.1	48.8	75.9	95.1	110.8	130.6	152.9
5	5.25	25.2	41.2	61.6	76.4	88.6	104.1	121.8
6	4.43	26.2	46.8	74.9	94.7	110.7	130.8	153.4
6	6.13	24.5	42.0	64.7	80.8	94.0	110.7	129.5
7	5.42	24.3	44.5	73.1	93.2	109.4	129.6	152.1
7	7.12	23.4	41.5	65.9	83.0	96.9	114.4	134.1
8	6.53	22.6	42.1	70.6	91.0	107.3	127.5	149.9
8	9.07	21.7	38.9	62.5	79.0	92.4	109.2	128.1
9	7.72	21.1	39.8	68.3	88.9	105.2	125.4	147.8
9	10.68	20.4	37.3	61.1	78.0	91.4	108.3	127.2
10	9.01	19.9	37.8	65.9	86.5	102.9	123.1	145.4
10	12.45	19.3	35.7	59.5	76.4	89.9	106.7	125.5
12	11.31	18.8	36.2	64.5	85.9	102.9	123.8	146.7
12	17.78	17.0	31.8	54.0	69.9	82.6	98.3	115.8
H-beams								
4	4.85	....	33.2	51.7	64.8	75.5	89.0	104.2
5	6.63	....	29.4	48.5	62.0	72.9	86.4	101.5
6	8.04	....	26.0	45.5	59.8	71.2	85.2	100.6
6	9.40	....	25.4	43.6	56.7	67.2	80.2	94.5
8	11.51	....	21.0	39.4	54.5	67.0	82.3	98.9
8	13.32	....	20.8	38.4	52.4	63.8	77.8	92.9

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10, page 37) to determine the critical compressive stresses at which beams of the various aluminum alloys will buckle sidewise.

TABLE 15—VALUES OF EQUIVALENT SLENDERNESS RATIO FOR COMPRESSION FLANGES OF BEAMS—Concluded

Laterally unsupported length of compression flange=L



Critical compressive stress applies to flange at or near the center of the laterally unsupported length.

Equivalent slenderness ratio $= \frac{KL}{r}$

L = laterally unsupported length of compression flange in inches

K = factor representing end conditions of laterally unsupported length, same as for columns

r = equivalent radius of gyration of compression flange defined on page 48

Standard channels		Equivalent slenderness ratio of compression flange, $\frac{KL}{r}$, for various values of effective unsupported length						
Depth Inches	Weight Lb./ft.	KL=24 inches	KL=48 inches	KL=96 inches	KL=144 inches	KL=192 inches	KL=264 inches	KL=360 inches
3	1.46	37.5	56.5	81.4	100.0	115.6	135.7	158.5
3	2.13	30.7	45.1	64.5	79.2	91.5	107.4	125.4
4	1.90	42.9	61.5	87.3	107.0	123.6	145.0	169.3
4	2.58	33.7	51.3	74.2	91.2	105.5	123.8	144.7
5	2.38	37.0	59.9	89.0	110.1	127.6	149.9	175.3
5	4.09	29.9	45.6	66.0	81.2	93.9	110.3	128.8
6	2.91	35.5	59.3	89.8	111.6	129.6	152.4	178.3
6	4.63	30.9	48.9	71.8	88.6	102.6	120.5	140.8
7	3.47	33.8	58.1	89.6	112.0	130.3	153.5	179.7
7	6.13	29.0	46.2	68.1	84.1	97.4	114.4	133.8
8	4.38	31.7	55.6	87.1	109.3	127.4	150.6	175.8
8	6.67	29.0	47.9	72.0	89.3	103.6	121.9	142.6
9	4.74	30.4	54.6	87.6	110.8	129.6	153.2	179.6
9	8.90	26.7	44.1	66.2	82.1	95.2	112.0	131.0
10	5.43	28.8	52.6	86.0	109.5	128.4	152.0	178.5
10	10.67	25.5	42.5	64.2	79.8	92.6	108.9	127.4
12	7.63	25.8	47.9	80.1	103.1	121.4	144.1	169.5
12	12.45	24.2	42.5	66.8	83.9	97.8	115.3	135.1
Special channels								
2	1.253	31.0	45.4	64.8	79.5	91.8	107.7	125.8
2½	1.277	38.3	55.9	79.8	97.9	113.1	132.7	155.0
3	2.30	27.5	42.4	61.7	76.0	87.9	103.2	120.6
3	2.78	25.0	37.6	54.2	66.6	77.0	90.4	105.6
4	3.41	19.9	29.6	42.5	52.2	60.4	70.8	82.8
5	3.19	23.1	38.7	58.5	72.7	84.5	99.4	116.2
5	4.88	24.7	39.1	57.4	70.8	82.0	96.4	112.6
5	5.99	20.5	33.1	49.0	60.6	70.2	82.5	96.5
6	5.94	22.4	37.6	57.0	70.9	82.4	96.9	113.4
6	6.10	19.4	34.5	55.1	69.5	81.2	95.9	112.4
8	6.62	24.1	42.9	68.4	86.3	100.8	119.0	139.5
8	8.09	19.4	35.9	58.0	73.5	86.0	101.8	119.4
10	8.84	20.8	38.4	63.7	81.6	96.0	113.8	133.7
10	10.34	20.3	36.8	59.9	76.2	89.3	105.6	124.0

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10, page 37) to determine the critical compressive stresses at which beams of the various aluminum alloys will buckle sidewise.

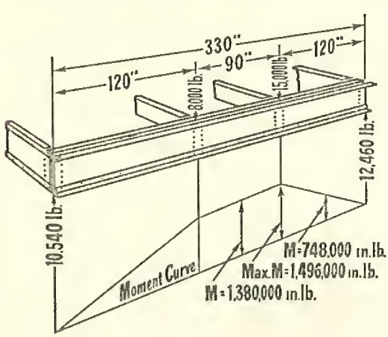
bers where the loading is likely to be eccentric with respect to the shear center, thereby introducing a definite torque on the member in addition to the bending. In all such cases involving combined torsion and bending, and in cases of unsymmetrical bending, the foregoing method of analysis of lateral stability does not apply. It is usually sufficient in such cases to calculate the maximum combined flange stress and to keep this stress within the safe allowable working stress limits of the flange material.

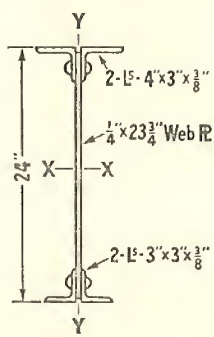
Double-web box girders, because of their tube-like cross section, are very much stiffer in torsion than single-web girders of comparable size. For the depth-width ratios ordinarily encountered in design, double-web box girders are so stiff in torsion that lateral buckling failures of the compression flange are of no importance in structural design, and therefore it is not necessary to make any reduction in allowable stress because of the slenderness ratio or length-width ratio of the flange. The allowable stress on the compression flange of such members is usually restricted by the possibility of local buckling of the compression cover plate.

Example 5. Check flange stress in plate girder for loading shown in sketch, using the following allowable working stresses, 61S-T6 alloy:

Tension on net area, factor of safety of 2.5 on the typical yield strength, $= \frac{40{,}000}{2.5} = 16{,}000$ lb./sq. in.

Compression on gross area, factor of safety of 2.5 on critical stress, with upper limiting value equal to tensile allowable stress = 16,000 lb./sq. in.





S (compression) = 125 in.^{3}

S (tension) = 114 in.^{3}

$I_Y = 25.0$ in.^{4}

$J = 0.580$ in.^{4}

$I_F = 17.4$ in.^{4}

These section elements are taken from page 144.

Calculated maximum tensile stress on net area (page 144)
$= \frac{1{,}496{,}000}{114} \times 1.13 = 14{,}800$ lb./sq. in. (less than 16,000, therefore satisfactory).

Calculated maximum compressive stress on gross area
$= \frac{1{,}496{,}000}{125} = 12{,}000$ lb./sq. in.

This maximum stress occurs at a point of lateral support where no lateral bending can occur, therefore it is checked against the upper limiting compressive stress, 16,000 lb./sq. in. and found to be satisfactory. (For final check, see Example 6.)

Calculated compressive stress at center of 90″ unsupported length
$= \frac{1{,}380{,}000}{125} = 11{,}000$ lb./sq. in.

Equivalent radius of gyration, assuming K=0.8 (page 48),

$$= \sqrt{\frac{0.2}{125}\sqrt{25.0\left[0.580\ (0.8 \times 90)^2 + 13.1 \times 17.4 \times \overline{24}^2\right]}} = 1.71''.$$

Equivalent slenderness ratio $= \frac{0.8 \times 90}{1.71} = 42$

Critical flange stress (Table 10, 61S-T6 alloy) $= 48{,}000 - 400 \times 42$
$= 31{,}200$ lb./sq. in.

Allowable working stress $= \frac{31{,}200}{2.5} = 12{,}500$ lb./sq. in.

This allowable stress is greater than the calculated stress, 11,000 lb./sq. in., therefore the flange is safe for the 90″ unsupported length.

Calculated compressive stress at center of 120″ unsupported length
$= \frac{748{,}000}{125} = 5980$ lb./sq. in.

Equivalent radius of gyration, assuming K=0.9,

$$= \sqrt{\frac{0.2}{125}\sqrt{25.0\left[0.580\ (0.9 \times 120)^2 + 13.1 \times 17.4 \times \overline{24}^2\right]}} = 1.72''.$$

Equivalent slenderness ratio $= \frac{0.9 \times 120}{1.72} = 63$

Critical flange stress $= 48{,}000 - 400 \times 63 = 22{,}800$ lb./sq. in.

Allowable working stress $= \frac{22{,}800}{2.5} = 9120$ lb./sq. in.

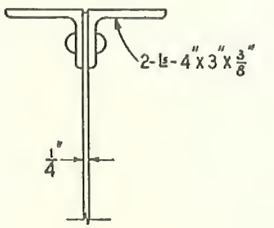
This allowable stress is greater than the calculated stress, 5980 lb./sq. in., therefore the flange is safe for the 120″ unsupported length.

Local Buckling of Compression Flanges

The compression flanges of beams and girders may fail by local buckling of some component part if relatively thin material is used in the construction of the flange. In order to design such members safely and economically, it is necessary to check the allowable compressive working stress not only for stability of the flange as a

whole, but also for local buckling, the final allowable working stress for the flange being the lower of the values arrived at in this manner. The critical buckling stresses for flat plates forming parts of the compression flanges of beams may be determined in the same manner as already given for flat plates in edge compression. Suitable factors of safety should be used with these critical stresses.

Example 6. Check the plate girder used in Example 5 to see if local buckling of the outstanding legs of the 4″ × 3″ × ⅜″ compression flange angles controls the design.



$\frac{b}{t}$ for 4″ leg $= \frac{4.00-0.375}{0.375} = 9.7.$

The equivalent slenderness ratio for this member is between the following (page 41):

$5.1\frac{b}{t}$ (one edge simply supported, other edge free)

$2.9\frac{b}{t}$ (one edge built in, other edge free)

This flange is nearer the second condition, the edge of the 4″ leg being restrained not only by the 3″ leg but also by the web.

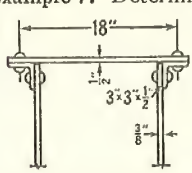
Assume equivalent slenderness ratio $= 3.5\frac{b}{t} = 3.5 \times 9.7 = 34.$

Critical stress (Table 10, 61S-T6 alloy) $= 48{,}000 - 400 \times 34$
$= 34{,}400$ lb./sq. in.

Allowable working stress $= \frac{34{,}400}{2.5} = 13{,}800$ lb./sq. in.

This allowable stress is greater than the maximum calculated stress, 12,000 lb./sq. in. (Example 5), therefore local buckling of the outstanding leg does not control the design of the compression flange.

Example 7. Determine allowable working stress for compression flange of box girder shown in sketch, using a factor of safety of 2 on the critical buckling stress of the cover plate, 61S-T6 alloy,



$$\frac{b}{t} = \frac{18}{\frac{1}{2}} = 36.$$

The equivalent slenderness ratio lies between $1.65\frac{b}{t}$ and $1.25\frac{b}{t}$ (edges simply supported and edges fixed, page 41).

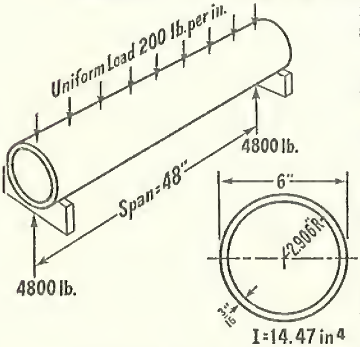
Assume equivalent slenderness ratio $= 1.5\frac{b}{t} = 1.5 \times 36 = 54.$

Critical stress (Table 10, 61S-T6 alloy) $= 48{,}000 - 400 \times 54$
$= 26{,}400$ lb./sq. in.

Allowable working stress $= \frac{26{,}400}{2} = 13{,}200$ lb./sq. in.

Tubular beams made of curved plates or thin seamless tubes should be checked for local compression buckling failures. The critical compressive stresses may be taken 25 per cent greater than those already given for similar members in direct compression.

Example 8. Check seamless tubular beam to see if compressive stress is safe for 61S-T6 alloy, using factor of safety of 3 on critical buckling stress.



$$\text{Max. moment} = \frac{200 \times \overline{48}^2}{8} = 57{,}600 \text{ in.-lb.}$$

Calculated compressive stress

$$= \frac{57{,}600 \times 3.0}{14.47} = 11{,}900 \text{ lb./sq. in.}$$

Ratio of radius to thickness

$$= \frac{R}{t} = \frac{2.906}{0.1875} = 15.5.$$

Equivalent slenderness ratio

$$= 4.7\sqrt{15.5} = 19 \text{ (page 46).}$$

Critical stress assuming edge compression (Table 10, 61S-T6 alloy) $= 48{,}000 - 400 \times 19 = 40{,}400$ lb./sq. in.

Critical stress for bending $= 40{,}400 \times 1.25 = 50{,}500$ lb./sq. in.

$$\text{Allowable working stress} = \frac{50{,}500}{3} = 16{,}800 \text{ lb./sq. in.}$$

This allowable stress exceeds the calculated compressive stress, 11,900 lb./sq. in., therefore the tube is safe.

Compression Buckling of Thin Webs

The webs of beams and girders are subjected to a horizontal compressive stress varying from zero at the neutral axis to a maximum at the compression flange. Thin webs may tend to buckle under the influence of these compressive stresses the same as other flat plates subjected to edge compression. To determine the critical stress, the following value of equivalent slenderness ratio should be used with the column formula for the material in question (Table 10):

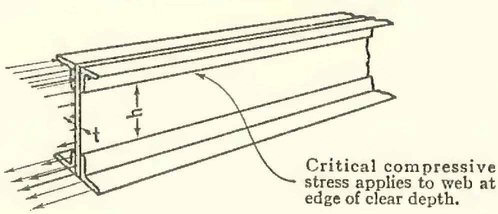
$$\text{Equivalent slenderness ratio} = 0.67\frac{h}{t},$$

where h = clear height of web in inches
t = thickness of web in inches.

The critical stress found in this manner applies to the condition which exists at the compression edge of the clear height of the web, adjacent to the compression flange. Table 16, page 56, gives values of equivalent slenderness ratio for various ratios of clear height to thickness.

Since compression buckling of thin webs does not often lead to complete failure of the member, the factor of safety to be used with the foregoing critical stresses need not be as conservative as those used in determining the more important allowable working stresses. Appearance is probably the most important item to be considered in arriving at a suitable factor of safety. In many instances the factor of safety may be allowed to approach very close to unity. Compression buckling of the web will control the design of the compression flange only in the case of very thin-web girders. More often the allowable compressive flange stress will be restricted by lateral buckling of the flange or some other consideration.

TABLE 16—EQUIVALENT SLENDERNESS RATIOS, $\frac{KL}{r}$, FOR WEBS OF BEAMS



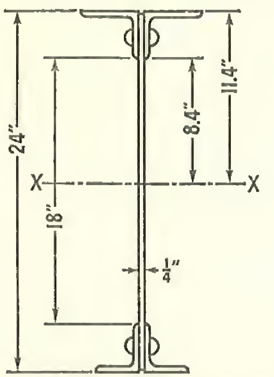
$$\frac{h}{t} = \frac{\text{clear depth of web}}{\text{thickness of web}}$$

$$\text{Equivalent slenderness ratio} = 0.67\ \frac{h}{t}$$

$\frac{h}{t}$	$\frac{KL}{r}$	$\frac{h}{t}$	$\frac{KL}{r}$
10	7	120	81
20	13	140	94
30	20	160	107
40	27	180	121
50	34	200	134
60	40	220	148
70	47	240	161
80	54	260	174
90	60	280	188
100	67	300	201

These values of equivalent slenderness ratio, $\frac{KL}{r}$, may be used directly in the column formulas (Table 10) to determine the critical compressive stresses at which plates of various aluminum alloys will buckle.

Example 9. Check the plate girder used in Example 5 to see if compression buckling of the web controls the design.



Calculated maximum compressive stress at top of clear height of web

$$=12{,}000\times\frac{8.4}{11.4}=8800 \text{ lb./sq. in.}$$

Equivalent slenderness ratio of web (page 55) $=0.67\times\frac{h}{t}=0.67\times\frac{18}{0.25}=48$

Critical stress (Table 10, 61S-T6 alloy) $=48{,}000-400\times48=28{,}800$ lb./sq. in.

Allowable working stress (factor of safety of 2.0) $=\frac{28{,}800}{2.0}=14{,}400$ lb./sq. in.

This allowable stress is greater than the calculated stress, 8800 lb./sq. in., therefore compression buckling of web does not control the design.

Combined Bending and Direct Compression

When a short, compact member is subjected to combined bending and direct compression, the basic allowable working stresses in tension and compression apply, because no stability problem is involved. The same is true for longer members, provided the maximum stresses occur at or near the ends of the unsupported length. A longer member in which the maximum stresses occur at or near the center of the unsupported length, however, will function partly as a beam and partly as a column, and the allowable compressive working stress must be selected accordingly. An allowable bending stress selected in accordance with the following formula will give a factor of safety in combined bending and compression which is consistent with those used separately in bending and compression.

Maximum bending stress (compression) on extreme fiber, which may be permitted at or near center of unsupported length, in addition to direct compression, $\frac{P}{A}$,

$$=\left(f_b-\frac{P}{A}\right)\left(1-\frac{\frac{P}{A}}{f_c}\right),$$

where $\frac{P}{A}$ = average compressive stress on cross section of member produced by column load in lb./sq. in.

f_b = allowable compressive working stress for member considered as a beam in lb./sq. in.

f_c = allowable working stress for member considered as a column tending to fail in plane of bending forces in lb./sq. in.

This formula for allowable bending stress is derived on the assumption that failure of the member will occur by bending in the plane of the bending forces, which is always the case if this plane coincides with the plane of least stiffness of the member. Members having bending forces applied in the plane of their greatest stiffness, however, may tend to fail by sidewise bending at right angles to the plane of the bending forces. To take care of this contingency, it is necessary to use the following additional formula for allowable bending stress:

Maximum bending stress (compression) on extreme fiber, which may be permitted at or near center of unsupported length, in addition to direct compression, $\frac{P}{A}$,

$$= f_b\sqrt{1-\frac{\frac{P}{A}}{f_c'}}$$

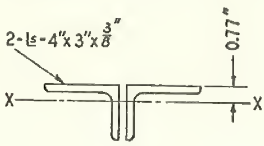
where f_c' = allowable working stress for member considered as a column tending to fail in direction normal to plane of bending forces in lb./sq. in.

f_b and $\frac{P}{A}$ are as previously defined.

For a member under combined loading, in which the bending forces are applied in the plane of greatest stiffness, it is necessary to apply each of the two foregoing formulas, and select the lower of the two values as the maximum bending stress to be permitted in addition to the direct compression, $\frac{P}{A}$.

In designing members for combined bending and direct compression, using the above formulas, it is rarely possible to determine the proper size of the member directly. The design procedure involves trial and error methods in which a member is selected and then checked to see if the calculated bending stress is within the allowable limits. It is always well to check the member finally selected for the possibility of column failure alone, about two or more axes. Obviously, the member selected for combined bending and compression should not be weaker than the one which would be selected for either loading considered separately.

Example 10. Check the chord used in Example 1 to see if, in addition to the 47,000 lb. axial load, it can safely carry a vertical bending load of 500 lb. concentrated at the center of one of the 60″ spans; factor of safety to remain 2.5, same as in Example 1.



I = 3.72 in⁴
A = 4.98 sq. in.

Check for axial load alone.

From Example 1, it is evident that the member is safe for column load alone because the calculated direct compression, $\frac{P}{A}$, is only 9440 lb./sq. in. compared to an allowable column stress, f_c, of 10,240 lb./sq. in.

Check for beam loading alone.

Bending moment at center of unsupported length, assuming K=0.8 same as in Example 1,

$$M = \frac{500 \times 0.8 \times 60}{4} = 6000 \text{ in.-lb.}$$

Calculated bending stress (compression),

$$\frac{Mc}{I} = \frac{6000 \times 0.77}{3.72} = 1240 \text{ lb./sq. in.}$$

Allowable working stress for member as a beam (compression flange),

$f_b = 12{,}160$ lb./sq. in. (factor of safety of 2.5 against buckling of outstanding leg, see Example 2a).

Member is therefore safe for bending alone.

Check for combined loading.

Maximum bending stress (compression) which may be permitted in addition to $\frac{P}{A}$,

$$= \left(f_b - \frac{P}{A}\right)\left(1 - \frac{\frac{P}{A}}{f_c}\right) = (12{,}160 - 9440)\left(1 - \frac{9440}{10{,}240}\right) = 213 \text{ lb./sq. in.}$$

Since this allowable stress is less than the calculated stress, 1240 lb./sq. in., a larger member would be needed to avoid reducing the factor of safety.

Example 10a. Recheck member above using factor of safety of 2.0 instead of 2.5.

New value of $f_b = 12{,}160 \times \frac{2.5}{2.0} = 15{,}200$ lb./sq. in.

New value of $f_c = 10{,}240 \times \frac{2.5}{2.0} = 12{,}800$ lb./sq. in.

New value of maximum bending stress which may be permitted in addition to $\frac{P}{A}$

$$= (15{,}200 - 9440)\left(1 - \frac{9440}{12{,}800}\right) = 1510 \text{ lb./sq. in.}$$

Since this allowable bending stress is greater than the calculated bending stress, 1240 lb./sq. in., the factor of safety against failure under combined loading is greater than 2.0.

Shear

The ultimate shear strengths and shear yield strengths of the various Alcoa Aluminum Alloys are given in Table 3, page 23. In arriving at suitable allowable working stresses in shear, both shearing yield and shearing ultimate should be taken into account and factors of safety comparable with those used in selecting allowable tensile working stresses should be employed. While it is common practice to apply the working stress in shear to the gross section of members, the possibility of shearing along the net section should not be overlooked, and the factor of safety to be used will depend somewhat on which way the allowable stress is to be used in design.

Shear Buckling of Flat Plates

When relatively thin, flat plates, such as the webs of girders, are subjected to shearing forces, they almost always buckle before the shearing yield strength of the material is reached. The critical shear buckling stress for such flat sheets simply supported along two edges, as in the case of the web of a plate girder without stiffeners, may be calculated by means of the following formula:

$$\text{Critical shear buckling stress} = \frac{51{,}000{,}000}{\left(\frac{b}{t}\right)^2},$$

where t = thickness of plate in inches
b = unsupported width of plate in inches.

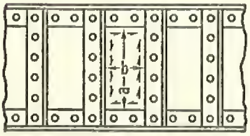
When a flat plate is simply supported on four sides, forming a rectangular panel in which the longer dimension, a, is less than four times the shorter dimension, b, the critical shear buckling stress is appreciably greater than in the foregoing case, and the formula may be written as follows:

$$\text{Critical shear buckling stress} = \frac{51{,}000{,}000}{\left(\frac{b}{t}\right)^2}\left[1+0.75\left(\frac{b}{a}\right)^2\right]$$

The above formulas are the same for all aluminum alloys, because they are based entirely on the modulus of elasticity of the material. The shearing yield strength of the material, taken from Table 3,

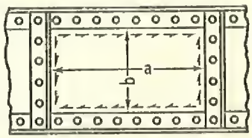
TABLE 17—CRITICAL SHEAR BUCKLING STRESSES FOR RECTANGULAR PANELS OF FLAT PLATE

$$\text{Critical stress (simply supported edges)} = \frac{51{,}000{,}000}{\left(\frac{b}{t}\right)^2}\left[1+0.75\left(\frac{b}{a}\right)^2\right]$$



$$\frac{b}{t} = \frac{\text{short dimension of panel}}{\text{thickness of plate}}$$

$$\frac{b}{a} = \frac{\text{short dimension of panel}}{\text{long dimension of panel}}$$



These values of critical stress apply to all the alloys, but the upper limiting value for any particular alloy is the value of the shearing yield strength given in Table 3.

$\frac{b}{t}$	$\frac{b}{a}=0$	$\frac{b}{a}=0.4$	$\frac{b}{a}=0.5$	$\frac{b}{a}=0.6$	$\frac{b}{a}=0.7$	$\frac{b}{a}=0.8$	$\frac{b}{a}=0.9$	$\frac{b}{a}=1.0$
40	31,880	35,700	37,850	40,480	43,590	47,180	51,240	55,780
42	28,910	32,380	34,330	36,720	39,540	42,790	46,480	50,600
44	26,340	29,500	31,280	33,460	36,020	38,990	42,350	46,100
46	24,100	26,990	28,620	30,610	32,960	35,670	38,740	42,180
48	22,140	24,790	26,290	28,110	30,270	32,760	35,580	38,740
50	20,400	22,850	24,230	25,910	27,900	30,190	32,790	35,700
52	18,860	21,120	22,400	23,950	25,790	27,910	30,320	33,010
54	17,490	19,590	20,770	22,210	23,920	25,890	28,120	30,610
56	16,260	18,220	19,310	20,650	22,240	24,070	26,140	28,460
58	15,160	16,980	18,000	19,250	20,730	22,440	24,370	26,530
60	14,170	15,870	16,820	17,990	19,370	20,970	22,770	24,790
62	13,270	14,860	15,760	16,850	18,140	19,640	21,330	23,220
64	12,450	13,950	14,790	15,810	17,030	18,430	20,020	21,790
66	11,710	13,110	13,900	14,870	16,010	17,330	18,820	20,490
68	11,030	12,350	13,100	14,010	15,080	16,320	17,730	19,300
70	10,410	11,660	12,360	13,220	14,230	15,400	16,730	18,210
75	9,070	10,160	10,770	11,520	12,400	13,420	14,580	15,870
80	7,970	8,930	9,460	10,120	10,900	11,790	12,810	13,950
85	7,060	7,910	8,380	8,970	9,650	10,450	11,350	12,350
90	6,300	7,050	7,480	8,000	8,610	9,320	10,120	11,020
100	5,100	5,710	6,060	6,480	6,970	7,550	8,200	8,930
110	4,220	4,720	5,010	5,350	5,760	6,240	6,780	7,380
120	3,540	3,970	4,210	4,500	4,840	5,240	5,690	6,200
130	3,020	3,380	3,580	3,830	4,130	4,470	4,850	5,280
140	2,600	2,910	3,090	3,310	3,560	3,850	4,180	4,550
150	2,270	2,540	2,690	2,880	3,100	3,360	3,640	3,970
175	1,670	1,870	1,980	2,120	2,280	2,460	2,680	2,910
200	1,280	1,430	1,510	1,620	1,740	1,890	2,050	2,230
250	820	910	970	1,040	1,120	1,210	1,310	1,430
300	570	640	670	720	780	840	910	990

Note: For all four edges built in, the critical stresses are approximately 65 per cent greater than shown above, but the shear yield strength is still the upper limiting value.

should be used as the upper limiting value of critical stress for each alloy. Table 17, page 61, gives calculated values for critical shear buckling stress for flat plates based on the foregoing formulas.

The factor of safety, to be used with the foregoing values in arriving at allowable working stresses for shear on flat plates supported on only two edges, generally should be about the same as that used in selecting allowable working stresses for columns, because a buckling failure of such a plate will often result in complete collapse of the structure. A smaller factor of safety may be used in the case of flat plates supported on all four edges, because a buckling failure of such a plate does not necessarily result in collapse if the edge stiffeners are stiff enough to function as compression struts. For example, if the thin web of a well-stiffened plate girder buckles under high shearing stresses, it will continue to transmit diagonal tension, and the stiffeners will begin to function as compression struts between the two flanges so that the girder will withstand considerable additional load, functioning almost as though it were a truss. In some fields of construction, thin-web girders are actually designed to transmit loads in this manner, buckling being entirely ignored in the interests of eliminating as much web material as possible.

It should be clear from the foregoing that the factor of safety to be used with the critical shear stresses on well-stiffened rectangular flat plates will be determined largely by the importance which is attached to the unsightly appearance of buckles in the sheet. Such flat sheets often buckle gradually rather than suddenly, so that slight buckling is sometimes visible at stresses as low as one half of the critical buckling stress. Therefore, where a high degree of flatness must be maintained even under maximum loading conditions, a generous factor of safety should be used in arriving at allowable shearing working stresses.

Example 11. Check girder used in Example 5 to see if web plate will resist shear buckling with a factor of safety of 2.5.
Maximum total shear on web, $V = 12{,}460$ lb.
Gross web area, $A = 23.75 \times 0.25 = 5.94$ sq. in.
Calculated average shear stress on web,

$$\frac{V}{A} = \frac{12{,}460}{5.94} = 2100 \text{ lb./sq. in.}$$

Minimum dimension of end panel of web, $b = 18''$ (clear height)
Other dimension of end panel of web, $a = 116''$ (approximate)

$$\frac{b}{t} = \frac{18}{0.25} = 72 \qquad \frac{b}{a} = \frac{18}{116} = 0.155$$

$$\text{Critical stress} = \frac{51{,}000{,}000}{\overline{72}^2}\,[1 + 0.75\ (0.155)^2]$$

$$= 9850\ [1.018] = 10{,}000\ \text{lb./sq. in.}$$

$$\text{Allowable working stress} = \frac{10{,}000}{2.5} = 4000\ \text{lb./sq. in.}$$

This allowable stress is considerably greater than the calculated stress, 2100 lb./sq. in., therefore the web easily resists shear buckling.

Note: If calculated stress had exceeded allowable stress, web could have been increased in thickness or web stiffeners could have been added to break up panel into rectangles having larger ratio of $\frac{b}{a}$.

Example 11a. Calculate the maximum shear stress on web of girder used in Example 11 to see if it is enough larger than average shear stress to make any difference in the design.

Area of cross section above neutral axis (page 144)
$= 4.98 + (11.4 - 0.125)\ 0.25 = 4.98 + 2.82 = 7.80$ sq. in.

Statical moment of this area about the neutral axis,
$Q = 4.98 \times 10.63 + 2.82 \times 5.64 = 69\ \text{in.}^3$

Calculated maximum shear stress on web,

$$\frac{VQ}{It} = \frac{12{,}460 \times 69}{1430 \times 0.25} = 2400\ \text{lb./sq. in.}$$

This stress is 14% greater than the average stress, 2100 lb./sq. in., calculated in Example 11, but is still well under the allowable working stress, 4000 lb./sq. in.

Shear Buckling of Cylindrical Shells

Thin-walled cylinders in transverse bending or torsion will fail by buckling in shear if the shear stresses exceed the following critical value:

$$\text{Critical shear stress} = \frac{7{,}300{,}000}{\left(\frac{D}{t}\right)^{3/2}}\,\beta$$

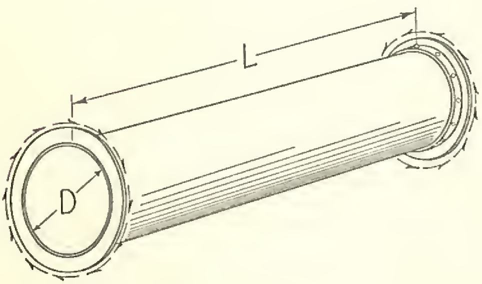
where D = mean diameter of cylinder in inches,
t = thickness of shell in inches,
β = unity for long unstiffened cylinders,
$\beta = 1.2\sqrt{\frac{\sqrt{D/t}}{L/D}}$ for cylinders in which the clear length "L" between circumferential stiffeners is such that the value of β is greater than unity.

When longitudinal stiffeners are used in conjunction with circumferential stiffeners so that the cylindrical surface is broken up into rectangular panels, the critical shear stress is greater than given by the above formula. In such cases it is sometimes helpful to calculate the critical shear stress for the rectangular panels as if they were flat (Table 17, page 61), knowing that the actual critical stress is somewhat higher because of the stiffening effect of the curvature.

Table 18 shows the critical shear buckling stresses for cylindrical shells calculated in accordance with the foregoing information.

TABLE 18—CRITICAL SHEAR BUCKLING STRESSES FOR CYLINDRICAL SHELLS

$$\text{Critical shear stress} = \frac{7{,}300{,}000}{\left(\frac{D}{t}\right)^{3/2}}\beta$$

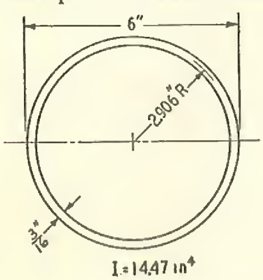


D = mean diameter of cylinder in inches,
t = thickness of shell in inches,
β = unity for long unstiffened cylinders,
$\beta = 1.2\sqrt{\frac{\sqrt{D/t}}{L/D}}$ for cylinders in which the clear length "L" between circumferential stiffeners is such that the value of β is greater than unity.

These values of critical stress apply to all the alloys, but the upper limiting value for any particular alloy is the value of the shearing yield strength given in Table 3, page 23.

$\frac{L}{D}$	$\frac{D}{t}=40$	$\frac{D}{t}=50$	$\frac{D}{t}=60$	$\frac{D}{t}=80$	$\frac{D}{t}=120$	$\frac{D}{t}=160$	$\frac{D}{t}=240$	$\frac{D}{t}=400$
0.10	.....	.....	.....	.....	69,740	48,820	29,320	15,490
0.25	.....	.....	.....	73,220	44,110	30,870	18,540	9,800
0.50	.....	93,180	74,200	51,790	31,190	21,770	13,110	6,930
1	87,090	65,880	52,460	36,610	22,060	15,390	9,270	4,900
2	61,580	46,580	37,100	25,890	15,590	10,890	6,560	3,460
5	38,960	29,460	23,470	16,360	9,860	6,890	4,150	2,190
10	28,860	20,830	16,590	11,580	6,970	4,870	2,930	1,550
20	28,860	20,650	15,710	10,200	5,550	3,610	2,070	1,100
30	28,860	20,650	15,710	10,200	5,550	3,610	1,960	910

Example 12. Check seamless tube used in Example 8, page 55, to see if shear buckling controls design.



Maximum shear, V = 4800 lb.

Calculated maximum shear stress (see Example 11a),

$$= \frac{VQ}{I(2t)} = \frac{V(2R^2t)}{I(2t)}$$

$$= \frac{4800[2(2.906)^2 \times 0.1875]}{14.47(2 \times 0.1875)}$$

$= 2800$ lb./sq. in.

$$\text{Critical shear stress} = \frac{7{,}300{,}000}{\left(\frac{D}{t}\right)^{3/2}}\beta$$

$$\beta = 1.2\sqrt{\frac{\sqrt{D/t}}{L/D}} = 1.2\sqrt{\frac{\sqrt{\frac{5.812}{0.1875}}}{\frac{48}{5.812}}} = 0.99$$

Since β is less than unity, a value of unity is used instead.

$$\text{Critical shear stress} = \frac{7{,}300{,}000}{\left(\frac{5.812}{0.1875}\right)^{3/2}} \times 1.00 = 42{,}300 \text{ lb./sq. in.}$$

This value of critical stress exceeds the shear yield strength of the material, 26,000 lb./sq. in., therefore the latter figure becomes the critical stress instead of the former.

$$\text{Allowable working stress} = \frac{26{,}000}{3} = 8670 \text{ lb./sq. in.}$$

This allowable stress is greater than the calculated stress, 2800 lb./sq. in., therefore shear buckling does not control the design.

Rivets in Shear and Bearing

Information on riveting of aluminum structures is given on pages 16 and 17. Table 19 gives the average shear strengths of driven rivets of aluminum alloys and steel, and Table 19A shows how these ultimate shear strengths should be reduced in those cases in which a rivet bears against a relatively thin plate. Table 20 shows the bearing yield strengths and bearing ultimate strengths of aluminum alloy plates and shapes when used with aluminum alloy or steel rivets or tightly fitted bolts or pins.

The allowable working stress for shear on rivets should have about the same relation to the ultimate shear strength shown in Table 19 that the basic tensile working stress has to the tensile ultimate strength of the material. The allowable working stress in bearing on plates and shapes should have about the same relation to the bearing yield and bearing ultimate given in Table 20 that the basic tensile working stress has to the tensile yield and tensile ultimate strength of the material. Table 29, page 158, gives shearing and bearing areas of driven rivets which are useful in designing riveted joints.

TABLE 19—AVERAGE ULTIMATE SHEAR STRENGTHS OF DRIVEN RIVETS

Alloy and Temper Before Driving	Driving Procedure	After Driving	
		Alloy and Temper	Shear Strength lb./sq. in.
A17S-T4	Driven cold, as received	A17S-T3	33,000
17S-T4	Driven cold, immediately after quench*	17S-T31	34,000
17S-T4	Driven at 930°F. to 950°F.*	17S-T41	33,000
24S-T4	Driven cold, immediately after quench*	24S-T31	42,000
53S-T61	Driven cold, as received	53S-T61	23,000
53S-T4	Driven at 960°F. to 1050°F.*	53S-T41	18,000†
61S-T6	Driven cold, as received	61S-T6	30,000
61S-T4	Driven at 990°F. to 1050°F.*	61S-T43	24,000
Steel	Driven cold, annealed	Steel	40,000
Steel	Driven hot	Steel	45,000

*Immediately after driving, the shear strengths of these rivets are about 75 per-cent of the values shown. On standing at ordinary temperatures the rivets age-harden to develop full strength, this action being complete in about 4 days for 17S-T31, 17S-T41 and 24S-T31 rivets and in about two weeks for 53S-T41 and 61S-T43 rivets.

†This shear strength is for rivets driven at temperatures of 960°F. to 980°F. The shear strength increases about 1000 lb. per square inch for each increase of 12°F. in driving temperature. Thus, if the driving temperature range is carefully maintained at 1030°F. to 1050°F., an average shear strength of 24,000 lb. per square inch will be developed in the driven rivets.

TABLE 19A—REDUCTION IN SHEAR STRENGTH OF ALUMINUM ALLOY RIVETS RESULTING FROM THEIR USE IN THIN PLATES AND SHAPES

Ratio of Rivet Diameter to Plate Thickness,* D/t	Per Cent Loss in Shear Strength		Ratio of Rivet Diameter to Plate Thickness,* D/t	Per Cent Loss in Shear Strength	
	Single Shear	Double Shear		Single Shear	Double Shear
1.5	0	0	2.7	0	15.6
1.6	0	1.3	2.8	0	16.9
1.7	0	2.6	2.9	0	18.2
1.8	0	3.9	3.0	0	19.5
1.9	0	5.2	3.1	0.4	20.8
2.0	0	6.5	3.2	0.8	22.1
2.1	0	7.8	3.3	1.2	23.4
2.2	0	9.1	3.4	1.6	24.7
2.3	0	10.4	3.5	2.0	26.0
2.4	0	11.7	3.6	2.4	27.3
2.5	0	13.0	3.7	2.8	28.6
2.6	0	14.3	3.8	3.2	29.9
			3.9	3.6	31.2
			4.0	4.0	32.5

*Thickness of thinnest plate in single shear joint.
Thickness of middle plate in double shear joint.

TABLE 20—BEARING STRENGTHS OF ALUMINUM ALLOY PLATES AND SHAPES REPRESENTATIVE OF MATERIAL HAVING THE TYPICAL PROPERTIES SHOWN IN TABLE 3

Alloy	Bearing ultimate strength, Lb./sq. in.	Bearing yield strength,[1] Lb./sq. in.	Alloy	Bearing ultimate strength, Lb./sq. in.	Bearing yield strength,[1] Lb./sq. in.
3S-O	34,000	15,000	24S-T4	129,000	77,000
3S-H12	37,000	27,000			
3S-H14	39,000	31,000	52S-O	57,000	26,000
3S-H16	42,000	35,000	52S-H32	71,000	43,000
3S-H18	46,000	40,000	52S-H34	78,000	50,000
			52S-H36	82,000	54,000
4S-O	54,000	23,000	52S-H38	86,000	58,000
4S-H32	65,000	35,000			
4S-H34	71,000	43,000	61S-O	38,000	19,000
4S-H36	78,000	50,000	61S-T4	73,000	34,000
4S-H38	84,000	54,000	61S-T6	94,000	64,000
14S-T4	114,000	59,000			
14S-T6	129,000	96,000			

[1]Bearing yield strength is the bearing stress which produces a permanent set of 2 per cent of the rivet hole diameter.

Note: These bearing values should be used only when the edge distance measured from the center of rivet hole in the direction of stressing is equal to or greater than twice the diameter of the rivet. For an edge distance of 1½ times the rivet diameter the values should be reduced approximately 15 per cent in the case of bearing yield strengths and 22 per cent in the case of bearing ultimate strengths.

Impact

The foregoing discussion of the strength, critical stresses and allowable working stresses is based on the assumption that all loadings are static. The entire discussion may be extended to include ordinary live-load conditions, however, if a suitable impact factor is used to represent dynamic effects of moving loads. Unusual dynamic effects such as uncushioned shock loads should be treated somewhat more carefully than the more normal loading conditions, and in such cases it is not always satisfactory to use a conventional assumed impact factor as an allowance for impact. A more thorough analysis, involving a study of the dissipation of the energy of the moving loads, is often the only safe procedure when designing for unusual conditions of impact in structural design.

Repeated Stress

When stresses are repeatedly applied to any metal for a large number of cycles, failure may occur by fatigue action even though the stresses represent an adequate factor of safety against steady stress. Fatigue action on ordinary structures occurs very rarely and usually only because there exists at some critical point a highly concentrated stress, considerably larger in magnitude than is indicated by ordinary design calculations. A study of the fatigue data in Table 5, page 25, and Table 6, page 26, indicates that even after making some allowance for such concentrated stresses, the Alcoa Aluminum Alloys still have a margin of safety against fatigue action. In the lower strength aluminum alloys, the allowable working stresses are almost never selected high enough to cause any concern about fatigue. In the higher strength aluminum alloys, however, allowable working stresses may be high enough to make it advisable to consider the possibility of fatigue action.

In studying repeated stress, it should be remembered that the maximum loadings assumed in ordinary structural design are usually much more severe than those which occur regularly in service. Furthermore, combinations of loadings are often assumed which occur very infrequently. An intelligent study of fatigue action in any structure usually involves a separate analysis of the stresses, using live loading conditions quite different from the maximum loadings assumed in the ordinary design. Ordinarily, dead-load stresses are not repeated. The live loads produce stress cycles which are superimposed on the steady dead-load stresses.

In using the fatigue data in Tables 5 and 6, it should be remembered that these data are obtained on smooth finished specimens in which stress concentrations are purposely minimized. Suitable allowance must always be made for re-entrant corners, notches, holes, joints and all other conditions which may produce localized high stresses. These localized high stresses, which have almost no effect on the static strength of the members, are of great importance in studying the effect of repeated stress.

A few general observations based on fatigue investigations at the Aluminum Research Laboratories may be helpful in connection with the design of aluminum alloy structures to resist repeated loads.

1. A hole well filled with a rivet causes less reduction of the fatigue strength of a structure than an open hole.

2. The reduction of the fatigue strength of a structure is greater for a rivet carrying stress than for a stitch rivet.

3. The reduction of the fatigue strength of a structure is greater for hot-driven steel rivets than for cold-driven steel rivets or for aluminum alloy rivets, driven either hot or cold.

4. Lap joints reduce the fatigue strength of a structure more than butt joints with double straps. This greater effect seems to be associated with the greater flexing which occurs in the lap joint. Any stiffening of the lap joint to prevent undue flexing under repeated loads tends to improve the fatigue characteristics of the joint.

DESIGN CONSIDERATIONS FOR ALUMINUM ALLOY STRUCTURES

THE PREVIOUS CHAPTER dealt with the selection of allowable working stresses for use in the design of aluminum alloy structures. The allowable working stresses are the controlling factor in the design of most of the members in a structure, but the final selection of the size and shape of the various members, as well as their arrangement, will often be influenced by other considerations. In this chapter, an attempt will be made to present information which will assist the designer in arriving at a well-balanced, economical design.

In many fields of structural design, there have been developed sets of limitations on the size and shape of members. For example, it is sometimes specified that the slenderness ratio of columns shall not exceed 200 or that the unsupported width of plates shall be not greater than 40 times the thickness. In different fields of design, such limitations vary considerably, and, since aluminum alloys are used in numerous types of construction, no attempt will be made in this book to establish such a set of limitations.

Freedom from the conventional limitations on size of parts should assist the designer in arriving at minimum weight of metal in the finished structure, a goal which is usually of primary importance in the design of aluminum alloy structures. On the other hand, freedom from such restrictions places an obligation on the designer to be especially careful in considering all loadings, both intentional and accidental, which the members may be called upon to resist in service. For example, almost any horizontal member in a structure may be called upon to support a man's weight at mid-span. A careful review of the conditions which will exist during fabrication and erection, as well as during the useful life of a structure, will often suggest other loadings for which members, particularly light bracing members, should be checked. A check of the strength of members on such a basis should accomplish the same purpose as the arbitrary size limitations and should do so with a net gain in both economy and safety.

Deflection

One of the most common limitations in structural design is that applying to deflections, and, since the aluminum alloys have a relatively low modulus of elasticity, such restrictions may require some special considerations in design. In all cases where deflection seems to be a controlling factor in the design, the reasons for limiting the deflection should be carefully examined. The selection of allowable deflections is often just as important as the selection of allowable working stresses.

The deflections of aluminum alloy members may be calculated from the conventional deflection formulas provided that the correct value of modulus of elasticity, 10,300,000 lb. per sq. in., is used.

For design purposes, particularly in the preliminary stages of a design, it is often unnecessary to strive for a high degree of precision. In such cases the following formula for approximating the deflection at mid-span for aluminum alloy beams of uniform cross section subjected to simple bending will be found extremely convenient:

$$\text{Deflection in inches} = \frac{fL^2}{100{,}000{,}000\ c},$$

where f = maximum bending stress on extreme fiber at or near mid-span in lb./sq. in.
L = span length in inches
c = distance from neutral axis to extreme fiber in inches.

A study of this deflection formula will show that for a given span length there are two ways the deflection can be reduced: one is to decrease the working stress, and the other is to increase the depth of the beam. The second method is preferable because it is most economical of material. It is well to remember this fact in proportioning members where stiffness is of primary importance.

Latticed Members and Trusses

In calculating deflections of beams by means of the foregoing formula, or by more precise deflection formulas, (Table 21, pages 79 to 82), it is common practice to neglect shearing deformations. This is justified in the case of solid-web beams and girders having span lengths which are fairly long in proportion to the depth of the beam, but it is not justified in the case of members with trussed or

latticed webs. If an attempt is made to calculate deflections of open-web members by means of the foregoing formula, or by substituting the moment of inertia of the member in one of the ordinary deflection formulas, the resulting calculated deflection will be considerably less than the actual deflection, the difference being the result of deformations of the web system. The deflections of members with trussed or latticed webs should always be calculated by some method applicable to truss construction, or at least some allowance for deformations of the web should be made.

The foregoing discussion of deflections of open-web members applies also to the calculation of stresses in such members. Members with latticed or trussed webs should be designed as trusses and not as beams, and the analysis should include the calculation of stresses in the web members and their connections.

Rivet Spacing in Built-up Members

Many of the members in a structure, particularly the larger members, are built up of plates and shapes riveted together as a unit. In such members the rivets connecting the component parts must be of the proper size and spaced so that the completed member will function as a unit. This is accomplished by spacing the rivets close enough so that: first, a suitable margin of safety is provided against column failure of the parts between rivets, and second, the longitudinal shear on any section can be transferred without exceeding the allowable working stresses in shear and bearing.

The spacing of rivets to prevent column failure of parts between adjacent rivets is simply a matter of adjusting the spacing so that the column strength of the parts is adequate. In order to determine the column strength of the part, the effective slenderness ratio of the part between rivets is substituted in the column formulas (Table 10, page 37), in the usual manner. This should be done not only for the component parts of columns and other compression members, but also for the compression flanges of beams, particularly the compression cover plates.*

The spacing of rivets to resist longitudinal shear is influenced principally by the magnitude of the longitudinal shear. The longitudinal shear varies along the length of a member in proportion to the total shear on the transverse cross section. It also varies with the location of the longitudinal section, being a maximum at the neutral axis and zero at the extreme fiber.

*The radius of gyration of a flat plate is equal to 29% of its thickness, regardless of its width.

The formula for calculating the longitudinal shear is as follows:

$$V_L = \frac{VQ}{I},$$

where V_L = shear on any longitudinal section between neutral axis and extreme fiber in lb./lin. in.
V = total shear on transverse section of member at point being investigated in lb.
Q = statical moment of gross area ($\int y dA$) of transverse cross section between longitudinal section and extreme fiber with reference to neutral axis of member in in.^{3}
I = moment of inertia of entire transverse section, gross area, in in.^{4}

When using this formula to calculate the shear on a line or lines of rivets, the longitudinal section may be irregular in shape so as to cut only the rivets in question.

The spacing of rivets to resist the longitudinal shear may be found from the following formula:

$$\text{Spacing in inches} = \frac{R}{V_L},$$

where R = value of one rivet in shear or bearing, whichever is smaller, expressed in lb.

Example 13. Determine the spacing of ⅝″ hot-driven 61S rivets connecting the compression flange angles to the web in the girder used in Example 5, page 52, allowable bearing stress to be 27,000 lb./sq. in.

Maximum shear (in end panel), $V = 12{,}460$ lb.

Statical moment of compression flange angles about neutral axis, $Q = (11.4 - 0.77)\ 4.98 = 52.9$ in.^{3}

Calculated longitudinal shear between flange angles and web,

$$V_L = \frac{VQ}{I} = \frac{12{,}460 \times 52.9}{1430} = 460 \text{ lb./lin. in.}$$

Value of one rivet (Table 29, page 159), $R = 0.164 \times 27{,}000 = 4430$ lb. (obviously, bearing controls the design of this double-shear rivet).

$$\text{Maximum allowable spacing of rivets} = \frac{R}{V_L} = \frac{4430}{460} = 9.6''.$$

This spacing may be considered the maximum allowable in the end panel, based on longitudinal shear alone.

The foregoing formula for the spacing of rivets to resist longitudinal shear applies to columns and other compression members as well as to beams. When a built-up member is subjected to a column load approaching its ultimate strength, the member bends sidewise and the axis of the member becomes tilted with respect to the line of action of the load. The member is therefore subjected to a transverse shear in the plane of bending equal to the load times the sine of the angle between the deflected axis of the member and

the line of action of the load. Since the maximum angle occurs at the ends of the effective length, KL, the maximum shear also occurs at this point. For design purposes the maximum shear on a column may be determined according to the following formula:

$$V = P\frac{(f_b - f_c')}{f_c} \times \frac{\pi r^2}{KLc},$$

where V = maximum transverse shear on a transverse section of column at ends of effective length, KL, in direction of assumed bending in lb.

P = column load in lb.

f_b = allowable extreme fiber stress (compression) on member considered as a beam in lb./sq. in.

f_c = allowable average stress on member considered as an axially loaded column in lb./sq. in.

f_c' = average stress, in lb./sq. in., which member will stand at allowable stresses. For straight axially loaded columns without side loads, f_c' is identical with f_c. For other members f_c' should be determined in accordance with the formulas for combined bending and direct compression (page 57) and will be less than f_c because of the influence of eccentricities and side loads.

r = radius of gyration, same as that used in determining f_c in inches

KL = effective length of member, same as used in determining f_b and f_c in inches

c = distance from centroidal axis to extreme fiber corresponding to f_b in inches.

It is important in the foregoing formula that the values of f_b, f_c, f_c', KL, r and c be selected so that they are consistent with each other and consistent with the direction of bending assumed. Sometimes it may be desirable to investigate bending about two or more axes, or bending in opposite directions about the same axis. More often, however, the transverse shear will be needed in a given direction, and the direction of bending can be selected accordingly.

It should be noted that the value of V given by the above formula applies to a transverse section at the ends of the effective length, KL. The value at the center of the effective length, KL, is zero. Between the center and the end, the value of V on any section may be approximated by direct interpolation.*

The value of V for columns as defined in the foregoing formula is that produced by the column load only. To this should be added the shear produced by any transverse loads which may exist. This combination may be substituted directly in the foregoing formula for longitudinal shear, V_L, which in turn may be used to determine the spacing of rivets. The combined transverse shear, V, may also be

*In cantilever compression members loaded so that the line of action of the load is always parallel to its original position ($K=2.0$), the free end corresponds to the point of maximum shear, V, and the built-in end corresponds to the center of effective length at which the value of V is zero.

used in designing latticing for compression members. Knowing the maximum transverse shear and the approximate distribution of shear along the length of the member, the latticing can be designed to resist the tensile and compressive forces acting on the individual bars. If batten plates are to be used instead of latticing, they should be close enough together so that the bending stresses, introduced into the longitudinal members by the transverse shear acting between batten plates, are not excessive.

Example 14. Determine spacing of ⅝″ hot-driven 61S rivets required to make the two angles function as a unit in the chord member used in Example 1, allowable shear stress to be 8000 lb./sq. in.

Check for column failure of individual angles.

Calculated column stress, $\frac{P}{A}=9440$ lb./sq. in.

Corresponding $\frac{KL}{r}$ from column formula (factor of safety of 2.5)

$$=\frac{48{,}000-9440\times 2.5}{400}=61.0$$

Least radius of gyration of individual angle $=0.64''$.

Maximum value of KL for individual angle $=61.0\times 0.64=39.0''$.

Maximum value of L for individual angle, between rivets, assuming K value of seven-tenths, $=39.0/0.7=55.7''$.

Check for longitudinal shear.

In order to produce longitudinal shear on the rivets connecting the two angles, the member must bend in the horizontal plane about axis Y-Y. For bending in this plane, the following values are found:

$$\frac{KL}{r}=\frac{0.8\times 120}{1.91}=\frac{96}{1.91}=50$$

$f_c=f_c'=(48{,}000-400\times 50)\div 2.5=11{,}200$ lb./sq. in.

$f_b=32{,}000\div 2=16{,}000$ lb./sq. in. (factor of safety of 2 against guaranteed minimum yield strength).

Maximum transverse shear,

$$V=P\frac{(f_b-f_c')}{f_c}\,\frac{\pi r^2}{KLc}=47{,}000\,\frac{(16{,}000-11{,}200)}{11{,}200}\,\frac{\pi\times\overline{1.91}^2}{96\times 4.19}=574\text{ lb.}$$

Maximum longitudinal shear,

$Q=2.49\times 1.45=3.61$ in.^{3} (statical moment of one angle about axis Y-Y)

$I=Ar^2=4.98\times\overline{1.91}^2=18.2$ in.^{4}

$$V_L=\frac{VQ}{I}=\frac{574\times 3.61}{18.2}=114\text{ lb./lin. in.}$$

Allowable shear value of one rivet (Table 29, page 159), $R=0.338\times 8000=2700$ lb.

Spacing of rivets to resist longitudinal shear $=\frac{2700}{114}=23.7''$.

This is the controlling spacing for the rivets joining the two angles because it is less than the 55.7″ required to prevent column failure of the individual angles between rivets.

Web Stiffeners at Concentrated Loads

In the foregoing chapter, formulas are given for determining the critical shear stress on the webs of beams and girders, and it is pointed out that shear buckling is a determining factor in the spacing of web stiffeners. Critical shear, however, is only one of the considerations controlling the spacing of web stiffeners, such stiffeners also being necessary at certain points of concentrated load or reaction. In order to check whether or not a stiffener is needed at points of concentrated load or reaction, it is necessary to calculate the average stress in the web both adjacent to the loaded flange and at the center of the clear height. The following two formulas may be used:

$$\text{Calculated stress in web adjacent to loaded flange} = \frac{P}{tb}.$$

$$\text{Calculated stress in web at center of clear height} = \frac{P}{t(b+ah)}.$$

Where P = concentrated load or reaction in lb.
t = web thickness in inches
b = length along flange over which P is assumed to be distributed in inches
h = clear height of web in inches
a = 1.0 for intermediate loads or reactions
a = 0.5 for loads or reactions at or near end of member.

The stress calculated by the first of the above two formulas should not exceed the basic allowable compressive stress on the web, and the stress calculated by the second of the above two formulas should not exceed the allowable stress on the web considered as a column over a length equal to the clear height.* In case either of these allowable stresses is exceeded, it is necessary to strengthen the web by applying stiffeners having a close bearing against the flanges. Such stiffeners must, of course, make up any deficiency in area adjacent to the loaded flange as well as provide sufficient column strength to resist the concentration.

In the case of built-up plate girders, the investigation of stresses in the web adjacent to the loaded flange should also include a check on the rivets to make sure that the latter are capable of transferring safely the concentration from the flange to the web without exceeding the allowable stresses in shear and bearing. When a concentrated load or reaction occurs at a section in which there is considerable longitudinal shear, the stress in the rivets should be calculated for a combination of the two conditions. Since the forces from

*The radius of gyration of a flat plate is equal to 29% of its thickness, regardless of the width.

these two conditions are usually not acting parallel to each other, they are not directly additive, the maximum force being obtained from the well-known parallelogram law.

Sometimes it may be necessary to investigate the need for additional stiffeners to resist concentrated loads which occur between stiffeners spaced according to some other consideration. This is particularly true in the case of a concentrated load moving along the flange. Under such circumstances, the stress adjacent to the loaded flange is checked exactly as outlined on previous page, but in checking the stresses at the center of the clear height, advantage may be taken of the stiffening effect of adjacent stiffeners already in place. This is done in determining the allowable column stress in the web. Instead of using the clear height of the web as the length of the column, a reduced length is used as follows:

$$\text{Effective clear height of web} = \frac{h}{\sqrt{1+2\left(\frac{h}{s}\right)^2}},$$

where s = twice the distance from concentrated load to nearest stiffener in inches

h = clear height of web in inches.

Connections and Splices

The design of connections and splices in structural members is equally as important as the design of the members themselves. It is highly desirable, of course, that the rivets in connections and splices be arranged so that any axial loads on the members are transmitted without introducing eccentricities. Where it is impossible to avoid such eccentricities, an estimate of their magnitude should be made and their effect should be taken into account in the calculation of stresses in the members. In designing joints which are required to transmit both moment and shear, the stresses in the rivets should be calculated, taking into account both factors. This condition is particularly important in end connections of small beams in which only a few rivets are used to connect the clip angles to the web. In such cases it will often be found that the bending moment on this group of rivets is more severe than the shear.

Care should be taken in designing riveted joints to have the rivets stressed principally in shear and bearing rather than in tension. This is particularly true in joints in which the forces are repeated, because rivets are not well adapted for transmitting repeated ten-

sile loadings. Where such tensile loadings cannot be eliminated, bolts should be substituted for rivets.

Vibration

It is sometimes necessary in structural design to consider the harmful effects of vibration of certain members or of the structure as a whole. In such cases it is necessary to make sure that the natural frequency of vibration of a structure as a whole, or any part of the structure, does not synchronize with the frequency of some impulse which may be repeated for a considerable number of times. It is desirable that the natural frequencies of the structure and its parts lie outside of a range from one-half to twice the frequency of these impulses. The natural frequency of a structure or member may be found approximately by means of the following formula:

Natural frequency of vibration, cycles per second,

$$=\frac{3.13}{\sqrt{D}},$$

where D = deflection at the center of the span of the structure or member resulting from its own weight plus any other weights attached to the member.

In the case of horizontal members, the deflection D is calculated in the ordinary manner, but in the case of members whose position is other than horizontal, the deflection is calculated as though the member were in a horizontal position. This use of the deflection is simply a convenient method of taking into account the modulus of elasticity of the material, the span length of the member, and the magnitude and distribution of the mass which is in motion when the member is vibrating.

Example 15. Find the natural frequency of vibration of the girder used in Example 5, page 52, assuming the loads shown are attached to and vibrate with the girder.

Calculated deflection at center of span, $D = 1.06''$

$$\text{Natural frequency of vibration} = \frac{3.13}{\sqrt{1.06}} = 3.04 \text{ cycles per second.}$$

Any impulses to which this girder may be subjected should not be repeated steadily in the range from 1.5 to 6 cycles per second. If the frequency of the impulses should lie within this range, stresses might be built up in the member exceeding any ordinary impact allowance which might be made to take care of such dynamic effects.

Example 15a. Check the natural frequency of vibration of the above girder assuming no weights attached to it.

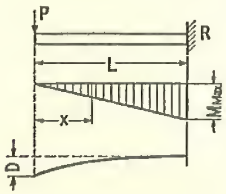
Calculated deflection at center of span, $D = 0.016''$

$$\text{Natural frequency of vibration} = \frac{3.13}{\sqrt{0.016}} = 24.8 \text{ cycles per second.}$$

BEAM FORMULAS

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS

1. CANTILEVER BEAM
Concentrated Load at Free End



Reaction $= P$

Moment at any point $= Px$

Maximum moment $= PL$

Maximum deflection $= \dfrac{PL^3}{3\ EI}$

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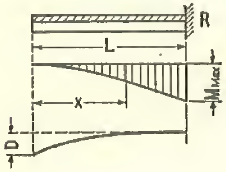
2. CANTILEVER BEAM
Uniform Load, w per unit of length, total load W



Reaction $= wL = W$

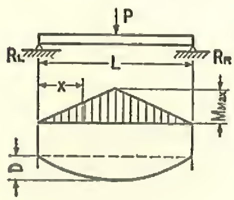
Moment at any point $= \dfrac{wx^2}{2} = \dfrac{Wx^2}{2L}$

Maximum moment $= \dfrac{wL^2}{2} = \dfrac{WL}{2}$

Maximum deflection $= \dfrac{wL^4}{8\ EI} = \dfrac{WL^3}{8\ EI}$

---

3. SIMPLE BEAM
Concentrated Load at Center



Reactions: $R_L = R_R = \dfrac{P}{2}$

Moment at any point:

$$x < \frac{L}{2},\ M = \frac{Px}{2}$$

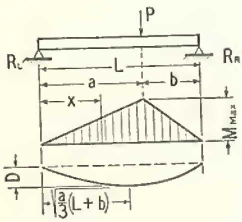
$$x > \frac{L}{2},\ M = \frac{P(L-x)}{2}$$

Maximum moment, at center $= \dfrac{PL}{4}$

Maximum deflection $= \dfrac{PL^3}{48\ EI}$

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS—Continued

4. SIMPLE BEAM
Concentrated Load at any point



Reactions: $R_L = \frac{Pb}{L}$, $R_R = \frac{Pa}{L}$

Moment at any point:

$$x < a,\ M = R_L x = \frac{Pbx}{L}$$

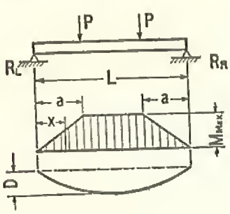
$$x > a,\ M = R_R(L-x) = \frac{Pa(L-x)}{L}$$

Maximum moment, where $x = a$, $M = \frac{Pab}{L}$

Maximum deflection, $D = \frac{Pab(L+b)\sqrt{3a(L+b)}}{27\ EIL}$

---

5. SIMPLE BEAM
Two equal, concentrated loads, symmetrically placed



Reactions: $R_L = R_R = P$

Moment at any point:

$$x < a,\ M = R_L x = Px$$

$$a < x < (L-a),\ M = Pa$$

$$x > (L-a),\ M = P(L-x)$$

Maximum moment: $M = Pa$

Maximum deflection $= \frac{Pa}{24\ EI}(3L^2 - 4a^2)$

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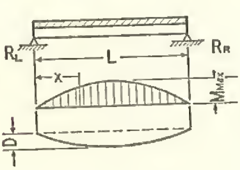
6. SIMPLE BEAM
Uniform Load, w per unit of length, total load W



Reactions: $R_L = R_R = \frac{wL}{2} = \frac{W}{2}$

Moment at any point:

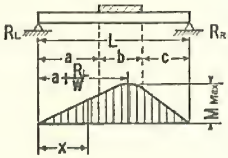
$$M = \frac{wx(L-x)}{2} = \frac{Wx(L-x)}{2L}$$

Maximum moment, at center: $M = \frac{wL^2}{8} = \frac{WL}{8}$

Maximum deflection: $D = \frac{5wL^4}{384\ EI} = \frac{5WL^3}{384\ EI}$

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS—Continued

7. SIMPLE BEAM
Uniform Load, w per unit of length, on part of span



Reactions: $R_L = \dfrac{bw(2c+b)}{2L}$, $R_R = \dfrac{bw(2a+b)}{2L}$

Moment at any point:

$$x < a,\ M = R_L x = \frac{bwx(2c+b)}{2L}$$

$$a < x < (a+b),\ M = R_L x - \frac{(x-a)^2 w}{2}$$

$$x > (a+b),\ M = R_R(L-x)$$

$$\text{Maximum moment} = \frac{bw(2c+b)\ [4aL+b(2c+b)]}{8L^2}$$

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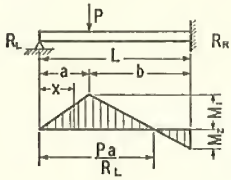
8. BEAM FIXED AT ONE END, SIMPLE SUPPORT AT OTHER
Concentrated Load at any point



Reactions: $R_L = \dfrac{Pb^2}{2L^3}(2L+a)$, $R_R = P - R_L$

Moment at any point:

$$x < a,\ M = R_L x = \frac{Pb^2 x}{2L^3}(2L+a)$$

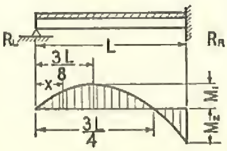
$$x > a,\ M = R_L x - P(x-a)$$

$$x = L,\ M_2 = \frac{-Pab}{2L^2}(L+a)$$

$$M_1 = \frac{Pab^2}{2L^3}(2L+a)$$

---

9. BEAM FIXED AT ONE END, SIMPLE SUPPORT AT OTHER
Uniform Load, w per unit of length



Reactions: $R_L = \dfrac{3}{8}wL$, $R_R = \dfrac{5}{8}wL$

Moment at any point:

$$x < L,\ M = wx\left(\frac{3L}{8} - \frac{x}{2}\right)$$

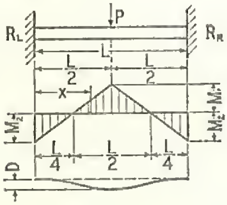
$$x = L,\ M_2 = \frac{-wL^2}{8}$$

$$M_1 = \frac{9wL^2}{128}$$

TABLE 21—BENDING MOMENTS AND DEFLECTIONS OF BEAMS—Concluded

10. BEAM FIXED AT BOTH ENDS

Concentrated Load at center



Reactions: $R_L = R_R = \frac{P}{2}$

Moment at any point:

$$x = 0,\ x = L,\ M_2 = \frac{-PL}{8}$$

$$x < \frac{L}{2},\ M = \frac{-P}{2}\left(\frac{L}{4} - x\right)$$

$$x > \frac{L}{2},\ M = \frac{P}{2}\left(\frac{3L}{4} - x\right)$$

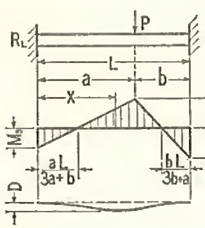
$M_1 = \frac{PL}{8}$

Maximum deflection $= \frac{PL^3}{192\ EI}$

---

11. BEAM FIXED AT BOTH ENDS

Concentrated Load at any point



Reactions: $R_L = \frac{Pb^2}{L^3}(L+2a),\ R_R = \frac{Pa^2}{L^3}(L+2b)$

Moment at any point:

$$x = 0,\ M_3 = \frac{-Pab^2}{L^2}$$

$$x < a,\ M = \frac{-Pab^2}{L^2} + R_L x$$

$$x > a,\ M = \frac{-Pa^2b}{L^2} + R_R(L - x)$$

$$x = L,\ M_2 = \frac{-Pa^2b}{L^2}$$

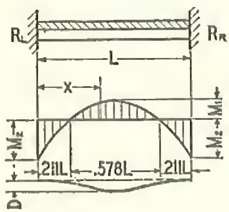
$M_1 = \frac{2Pa^2b^2}{L^3}$

Maximum deflection, $a > b$, $= \frac{2Pa^3b^2}{3\ EI\ (3a+b)^2}$

---

12. BEAM FIXED AT BOTH ENDS

Uniform Load, w *per unit of length, total load* W



Reactions: $R_L = R_R = \frac{wL}{2} = \frac{W}{2}$

Moment at any point:

$$x = 0,\ x = L,\ M_2 = \frac{-wL^2}{12} = \frac{-WL}{12}$$

$$x < L,\ M = \frac{-wL^2}{12} - \frac{wx^2}{2} + \frac{wLx}{2}$$

$M_1 = \frac{wL^2}{24} = \frac{WL}{24}$

Maximum deflection $= \frac{wL^4}{384\ EI}$

ELEMENTS OF SECTIONS

STRUCTURAL SHAPES, RECTANGLES, TUBES

AND FORMULAS

STRUCTURAL SHAPES

Elements of Sections

THE DATA given on the following pages include the section elements commonly used in design. All values have been computed on the basis of the nominal dimensions shown; the actual dimensions of a member will usually overrun slightly, depending on the condition of the rolls or die. Fillets and roundings have been included throughout all calculations except those for the torsion factor, J.

On the profiles shown, axes X-X and Y-Y are the axes of maximum and minimum moments of inertia, respectively, for sections having an axis of symmetry. Axis Z-Z is the axis of least moment of inertia for unsymmetrical sections. Each is the neutral axis for flexure in the plane at right angles to the axis.

8

The moment of inertia, I, is a convenient value representing the expression, $\int y^2 dA$, which appears in the derivation of the well-known flexure formula. The moment of inertia of any structural shape about a given axis, however, is obtained not by actual integration over the entire area, but by breaking the area up into a few convenient parts, calculating the individual moments of inertia of these parts about the axis in question by means of the theorem of parallel axes, and summing up these individual values. The term, I, appears in the formulas for deflections of beams in Table 21, pages 79 through 82.

The section modulus, S, about a given axis, may be defined as the quotient obtained by dividing the moment of inertia by the distance of the extreme fiber of the section from the axis considered $\left(S=\frac{I}{c}\right)$. This term is used in calculating extreme fiber stress in beams, the stress being the bending moment divided by the section modulus.

The radius of gyration, r, about a given axis, may be defined as the square root of the quotient obtained by dividing the moment of inertia by the area of the section $\left(r=\sqrt{\frac{I}{A}}\right)$. This term is used in the determination of column strength, the length of a member divided by its radius of gyration being the slenderness ratio.

The torsion factor, J, is a measure of the resistance of a section to twisting in simple torsion in much the same way that I is a measure of resistance to deflection in simple bending. For structural shapes this term is not the polar moment of inertia as it would be

for round rods or tubes, but it may be used in exactly the same manner to determine angle of twist for a given torque according to the formula:

$$\Theta = \frac{T}{JG},$$

where Θ = angle of twist, radians per inch of length
T = torque in inch-pound
J = torsion factor in in.^{4}
G = modulus of rigidity (3,850,000 lb./sq. in. for aluminum alloys).

The term J enters into the determination of the lateral stability of beams (page 48).

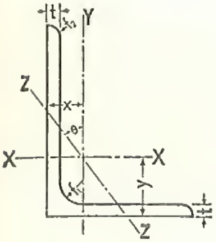
The weights given are for 14S alloy. The weights based on other alloys may be found as follows:

For 3S, multiply by 0.980
For 4S, and 61S multiply by 0.970
For 24S, multiply by 0.990
For 52S, multiply by 0.960

The range of sizes which Aluminum Company of America mills are capable of producing are indicated in the tables, but tools are not available for all sizes of shapes shown. Under the heading "Tools," shapes which are usually produced by rolling are shown by the notation "Rolls." In the case of shapes produced exclusively by extrusion, the die number is given. Contact nearest Alcoa Sales Office in regard to tools for the production of other shapes.

NOTE

ALCOA ALUMINUM STANDARD STRUCTURAL SHAPES are indicated by an asterisk (*) at the head of the column. This list has been developed on the basis of maximum utility and popularity. Selection of these STANDARD SHAPES by the designer is strongly recommended in the interest of quick delivery. Nonstandard shapes will be produced to order and at a higher price.



ANGLES

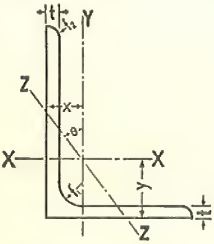
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size									
Size	Legs	1/2 x 1/2	5/8 x 5/8		3/4 x 3/8	3/4 x 3/4			
Size	t	1/16	3/32	1/8	3/32	1/16	3/32	1/8*	3/16*
Weight		0.071	0.134	0.169	0.120	0.108	0.159	0.207	0.297
Area		0.059	0.111	0.140	0.099	0.089	0.132	0.171	0.246
f_1		1/16	1/8	1/16	1/8	1/8	1/8	1/8	1/8
f_2		1/32	3/64	1/16	3/64	3/32	3/32	3/32	3/32
Axis X-X	I	0.0013	0.0037	0.0046	0.0054	0.0043	0.0063	0.0082	0.0112
Axis X-X	S	0.0038	0.0084	0.0109	0.0114	0.0079	0.0118	0.0157	0.0224
Axis X-X	r	0.150	0.183	0.182	0.232	0.220	0.219	0.219	0.214
Axis X-X	y	0.146	0.187	0.199	0.279	0.199	0.214	0.227	0.251
Axis Y-Y	I	0.0013	0.0037	0.0046	0.0009	0.0043	0.0063	0.0082	0.0112
Axis Y-Y	S	0.0038	0.0084	0.0109	0.0031	0.0079	0.0118	0.0157	0.0224
Axis Y-Y	r	0.150	0.183	0.182	0.094	0.220	0.219	0.219	0.214
Axis Y-Y	x	0.146	0.187	0.199	0.098	0.199	0.214	0.227	0.251
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	13° 44′	45° 0′	45° 0′	45° 0′	45° 0′
Axis Z-Z	I	0.0006	0.0015	0.0020	0.0006	0.0018	0.0026	0.0034	0.0049
Axis Z-Z	r	0.097	0.117	0.120	0.077	0.142	0.141	0.141	0.141
J		0.00008	0.00034	0.00081	0.00031	0.00012	0.00041	0.00098	0.0033
Tools		78-P	77-G	485	734-A	78-K	78-C	Rolls	Rolls

Size									
Size	Legs	1 x 5/8		1 x 3/4	1 x 1				
Size	t	1/8	1/4	1/8	1/16	3/32*	1/8*	3/16*	1/4*
Weight		0.226	0.418	0.245	0.147	0.216	0.283	0.411	0.529
Area		0.187	0.345	0.202	0.122	0.178	0.234	0.339	0.437
f_1		1/16	1/8	1/16	1/16	1/8	1/8	1/8	1/8
f_2		1/16	1/16	1/16	1/32	3/32	3/32	3/32	3/32
Axis X-X	I	0.0181	0.0306	0.0194	0.0118	0.0161	0.0208	0.0291	0.0361
Axis X-X	S	0.0279	0.0507	0.0288	0.0162	0.0223	0.0293	0.0424	0.0544
Axis X-X	r	0.312	0.298	0.309	0.311	0.301	0.298	0.293	0.287
Axis X-X	y	0.351	0.396	0.329	0.271	0.276	0.290	0.314	0.336
Axis Y-Y	I	0.0054	0.0089	0.0092	0.0118	0.0161	0.0208	0.0291	0.0361
Axis Y-Y	S	0.0117	0.0215	0.0169	0.0162	0.0223	0.0293	0.0424	0.0544
Axis Y-Y	r	0.170	0.161	0.214	0.311	0.301	0.298	0.293	0.287
Axis Y-Y	x	0.165	0.210	0.205	0.271	0.276	0.290	0.314	0.336
Axis Z-Z	Θ	20° 34′	9° 08′	28° 23′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
Axis Z-Z	I	0.0033	0.0084	0.0051	0.0048	0.0066	0.0085	0.0124	0.0162
Axis Z-Z	r	0.132	0.156	0.158	0.199	0.193	0.191	0.191	0.193
J		0.00106	0.00846	0.00114	0.00016	0.00055	0.00130	0.00439	0.01042
Tools		734-5	734-4	734-JJ	78-J	Rolls	Rolls	Rolls	Rolls

*See note on page 86.



ANGLES

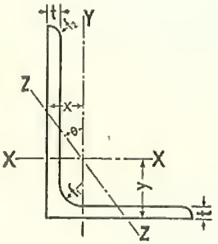
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Legs	1⅛ x 1⅛	1¼ x ¾	1¼ x 1	1¼ x 1¼				
	t	1/8	3/32*	1/8*	3/32	1/8*	3/16*	1/4*	5/16
	Weight	0.32	0.22	0.32	0.28	0.36	0.53	0.68	0.83
	Area	0.27	0.18	0.27	0.23	0.30	0.43	0.56	0.68
	f_1	3/16	3/32	1/8	3/32	3/32	3/32	3/32	3/32
	f_2	1/8	3/64	1/16	3/64	1/8	1/8	1/8	1/8
Axis X-X	I	0.030	0.029	0.040	0.033	0.042	0.059	0.074	0.088
	S	0.037	0.035	0.047	0.036	0.046	0.068	0.087	0.106
	r	0.33	0.40	0.39	0.38	0.37	0.37	0.36	0.36
	y	0.32	0.42	0.39	0.34	0.35	0.37	0.40	0.42
Axis Y-Y	I	0.030	0.008	0.023	0.033	0.042	0.059	0.074	0.088
	S	0.037	0.014	0.031	0.036	0.046	0.068	0.087	0.106
	r	0.33	0.21	0.29	0.38	0.37	0.37	0.36	0.36
	x	0.32	0.17	0.27	0.34	0.35	0.37	0.40	0.42
Axis Z-Z	Θ	45° 0′	19° 47′	31° 51′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.012	0.005	0.012	0.014	0.017	0.025	0.032	0.040
	r	0.21	0.16	0.21	0.24	0.24	0.24	0.24	0.24
	J	0.0015	0.0005	0.0015	0.0007	0.0016	0.0055	0.013	0.025
	Tools	78-U	734-FF	734-HH	78-Y	Rolls	Rolls	Rolls	

Size	Legs	1½ x ¾		1½ x ⅞	1½ x 1		1½ x 1¼		
	t	1/8*	3/16*	3/16	5/32*	1/4*	1/8*	3/16*	1/4*
	Weight	0.32	0.47	0.50	0.45	0.68	0.40	0.58	0.76
	Area	0.27	0.39	0.41	0.37	0.56	0.33	0.48	0.63
	f_1	1/8	1/8	1/8	5/32	3/16	3/16	3/16	3/16
	f_2	1/16	3/32	3/32	5/64	1/8	1/8	1/8	1/8
Axis X-X	I	0.061	0.085	0.090	0.080	0.117	0.070	0.100	0.127
	S	0.064	0.091	0.093	0.081	0.122	0.066	0.097	0.126
	r	0.48	0.47	0.47	0.47	0.46	0.46	0.46	0.45
	y	0.54	0.57	0.54	0.50	0.53	0.44	0.47	0.49
Axis Y-Y	I	0.010	0.014	0.022	0.027	0.040	0.044	0.063	0.079
	S	0.018	0.025	0.034	0.036	0.057	0.047	0.069	0.090
	r	0.20	0.19	0.23	0.27	0.27	0.37	0.36	0.36
	x	0.17	0.19	0.23	0.26	0.29	0.32	0.35	0.37
Axis Z-Z	Θ	14° 25′	13° 45′	18° 08′	23° 02′	22° 23′	33° 59′	33° 53′	33° 36′
	I	0.007	0.009	0.014	0.015	0.025	0.022	0.032	0.041
	r	0.16	0.16	0.18	0.20	0.21	0.26	0.26	0.26
	J	0.0015	0.0049	0.0052	0.0032	0.0130	0.0018	0.0060	0.0143
	Tools	734-EE	734-11	734-7	Rolls	Rolls	Rolls	Rolls	Rolls

*See note on page 86.



ANGLES

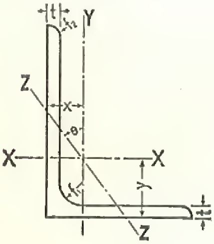
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.[4]
S = Section Modulus in in.[3]
r = Radius of Gyration in inches.
J = Torsion Factor in in.[4]

Size	Legs	1½ x 1½						1⅝ x 1¼	1¾ x 1⅛
	t	3/32	1/8*	3/16*	1/4*	5/16	3/8	1/8	3/16
	Weight	0.33	0.44	0.64	0.83	1.02	1.19	0.41	0.61
	Area	0.28	0.36	0.53	0.69	0.84	0.99	0.34	0.51
	f_1	3/16	3/16	3/16	3/16	3/16	3/16	1/8	3/16
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8	3/32
Axis X-X	I	0.058	0.074	0.107	0.135	0.161	0.184	0.087	0.152
	S	0.053	0.068	0.100	0.130	0.158	0.185	0.077	0.132
	r	0.46	0.45	0.45	0.44	0.44	0.43	0.51	0.55
	y	0.40	0.41	0.44	0.46	0.48	0.51	0.50	0.59
Axis Y-Y	I	0.058	0.074	0.107	0.135	0.161	0.184	0.045	0.049
	S	0.053	0.068	0.100	0.130	0.158	0.185	0.048	0.058
	r	0.46	0.45	0.45	0.44	0.44	0.43	0.36	0.31
	x	0.40	0.41	0.44	0.46	0.48	0.51	0.31	0.29
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	29° 55′	21° 47′
	I	0.024	0.031	0.044	0.057	0.070	0.083	0.024	0.029
	r	0.30	0.29	0.29	0.29	0.29	0.29	0.26	0.24
	J	0.0008	0.0020	0.0066	0.016	0.031	0.053	0.0019	0.0063
	Tools	78-JJ	Rolls	Rolls	Rolls	78-N	78-DD	734-2	734-E

Size	Legs	1¾ x 1¼			1¾ x 1¾					
	t	1/8*	3/16*	1/4*	3/32	1/8*	3/16*	1/4*	5/16*	3/8
	Weight	0.44	0.64	0.83	0.39	0.51	0.75	0.98	1.21	1.42
	Area	0.36	0.53	0.69	0.32	0.42	0.62	0.81	1.00	1.17
	f_1	3/16	3/16	3/16	3/32	3/16	3/16	3/16	3/16	3/16
	f_2	1/8	1/8	1/8	3/64	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.108	0.156	0.199	0.096	0.121	0.174	0.223	0.266	0.306
	S	0.090	0.132	0.172	0.075	0.094	0.139	0.181	0.221	0.259
	r	0.55	0.54	0.54	0.55	0.53	0.53	0.52	0.52	0.51
	y	0.54	0.57	0.60	0.47	0.47	0.50	0.52	0.55	0.57
Axis Y-Y	I	0.046	0.066	0.083	0.096	0.121	0.174	0.223	0.266	0.306
	S	0.048	0.071	0.092	0.075	0.094	0.139	0.181	0.221	0.259
	r	0.36	0.35	0.35	0.55	0.53	0.53	0.52	0.52	0.51
	x	0.30	0.32	0.35	0.47	0.47	0.50	0.52	0.55	0.57
Axis Z-Z	Θ	26° 22′	26° 08′	25° 47′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.026	0.037	0.048	0.039	0.050	0.072	0.093	0.113	0.134
	r	0.27	0.26	0.26	0.35	0.34	0.34	0.34	0.34	0.34
	J	0.0020	0.0066	0.016	0.0010	0.0023	0.0077	0.018	0.036	0.062
	Tools	Rolls	Rolls	Rolls	78-L	Rolls	Rolls	Rolls	Rolls	

*See note on page 86.



ANGLES

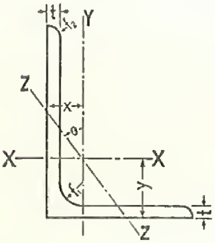
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.[4]
S=Section Modulus in in.[3]
r=Radius of Gyration in inches.
J=Torsion Factor in in.[4]

Size	Legs	2 x 1¼			2 x 1⅜	2 x 1½				
	t	1/8	3/16	1/4	1/4	1/8*	3/16*	1/4*	5/16	3/8*
	Weight	0.47	0.70	0.91	0.95	0.51	0.75	0.98	1.21	1.42
	Area	0.39	0.58	0.75	0.79	0.42	0.62	0.81	1.00	1.17
	f_1	3/16	3/16	3/16	1/4	3/16	3/16	3/16	3/16	3/16
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.158	0.228	0.291	0.302	0.17	0.24	0.31	0.37	0.43
	S	0.117	0.172	0.224	0.228	0.12	0.18	0.23	0.28	0.33
	r	0.63	0.63	0.62	0.62	0.63	0.62	0.62	0.61	0.60
	y	0.65	0.68	0.70	0.68	0.60	0.63	0.66	0.68	0.70
Axis Y-Y	I	0.047	0.068	0.086	0.114	0.08	0.12	0.15	0.18	0.20
	S	0.049	0.072	0.093	0.113	0.07	0.10	0.14	0.16	0.19
	r	0.35	0.34	0.34	0.38	0.44	0.43	0.43	0.42	0.41
	x	0.28	0.31	0.33	0.37	0.36	0.38	0.41	0.43	0.45
Axis Z-Z	Θ	21° 05′	20° 52′	20° 31′	24° 14′	28° 44′	28° 36′	28° 20′	28° 0′	27° 37′
	I	0.028	0.041	0.053	0.067	0.04	0.06	0.08	0.10	0.12
	r	0.27	0.27	0.26	0.29	0.32	0.32	0.32	0.32	0.32
	J	0.0021	0.0071	0.017	0.018	0.0023	0.0077	0.018	0.036	0.062
	Tools	734-P	734-N	734-12	734-KK	Rolls	Rolls	Rolls	734-20	Rolls

Size	Legs	2 x 1¾	2 x 2						2¼ x 1½
	t	1/4	1/8*	3/16*	1/4*	5/16*	3/8*	7/16	1/4
	Weight	1.07	0.59	0.87	1.14	1.40	1.65	1.89	1.07
	Area	0.88	0.49	0.72	0.94	1.16	1.37	1.57	0.88
	f_1	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.33	0.18	0.27	0.34	0.41	0.47	0.53	0.43
	S	0.24	0.13	0.19	0.24	0.30	0.35	0.39	0.29
	r	0.61	0.61	0.61	0.60	0.60	0.59	0.58	0.70
	y	0.62	0.53	0.56	0.58	0.61	0.63	0.65	0.76
Axis Y-Y	I	0.23	0.18	0.27	0.34	0.41	0.47	0.53	0.15
	S	0.18	0.13	0.19	0.24	0.30	0.35	0.39	0.14
	r	0.51	0.61	0.61	0.60	0.60	0.59	0.58	0.42
	x	0.49	0.53	0.56	0.58	0.61	0.63	0.65	0.39
Axis Z-Z	Θ	34° 44′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	23° 09′
	I	0.11	0.08	0.11	0.14	0.17	0.20	0.23	0.09
	r	0.36	0.40	0.39	0.39	0.39	0.39	0.39	0.32
	J	0.020	0.0026	0.0088	0.021	0.041	0.070	0.112	0.020
	Tools	734-13	Rolls	Rolls	Rolls	Rolls	Rolls		734-MM

*See note on page 86.



ANGLES

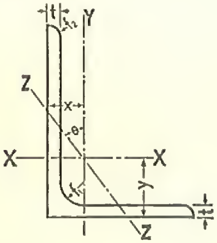
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.⁴
S=Section Modulus in in.³
r=Radius of Gyration in inches.
J=Torsion Factor in in.⁴

Size	Legs	2½ x 1¼			2½ x 1½				
	t	1/8	3/16	1/4	1/8	3/16*	1/4*	5/16*	3/8
	Weight	0.55	0.82	1.07	0.59	0.87	1.14	1.40	1.65
	Area	0.46	0.68	0.88	0.49	0.72	0.94	1.16	1.37
	f_1	3/16	1/4	1/4	1/4	1/4	1/4	3/16	1/4
	f_2	3/32	3/32	3/32	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.30	0.43	0.55	0.31	0.46	0.59	0.71	0.82
	S	0.18	0.27	0.35	0.19	0.27	0.36	0.44	0.51
	r	0.81	0.80	0.79	0.80	0.79	0.79	0.78	0.77
	y	0.87	0.89	0.92	0.80	0.84	0.86	0.89	0.91
Axis Y-Y	I	0.05	0.07	0.09	0.09	0.12	0.16	0.19	0.22
	S	0.05	0.08	0.10	0.07	0.11	0.14	0.17	0.20
	r	0.34	0.33	0.32	0.42	0.41	0.41	0.40	0.40
	x	0.25	0.28	0.30	0.32	0.35	0.37	0.39	0.42
Axis Z-Z	Θ	14° 45′	14° 29′	14° 10′	19° 40′	19° 38′	19° 25′	19° 06′	18° 42′
	I	0.03	0.05	0.06	0.05	0.08	0.10	0.12	0.14
	r	0.27	0.27	0.26	0.33	0.32	0.32	0.32	0.32
	J	0.0024	0.0082	0.020	0.0026	0.0088	0.021	0.041	0.070
	Tools	734-6	734-H		734-36	734-T	734-RR	734-8	

Size	Legs	2½ x 2						
	t	1/8*	3/16*	1/4*	5/16*	3/8*	7/16	1/2
	Weight	0.67	0.99	1.29	1.59	1.88	2.16	2.43
	Area	0.55	0.82	1.07	1.32	1.55	1.78	2.01
	f_1	1/4	1/4	1/4	1/4	1/4	1/4	1/4
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.34	0.50	0.65	0.78	0.91	1.02	1.13
	S	0.19	0.29	0.38	0.46	0.54	0.62	0.69
	r	0.79	0.78	0.78	0.77	0.76	0.76	0.75
	y	0.72	0.75	0.78	0.80	0.83	0.85	0.87
Axis Y-Y	I	0.20	0.29	0.37	0.44	0.51	0.57	0.63
	S	0.13	0.19	0.25	0.30	0.36	0.41	0.46
	r	0.60	0.59	0.58	0.58	0.57	0.57	0.56
	x	0.48	0.51	0.53	0.55	0.58	0.60	0.62
Axis Z-Z	Θ	31° 57′	31° 58′	31° 51′	31° 41′	31° 28′	31° 13′	30° 56′
	I	0.10	0.15	0.19	0.23	0.27	0.31	0.35
	r	0.43	0.42	0.42	0.42	0.42	0.42	0.42
	J	0.0029	0.010	0.023	0.046	0.079	0.126	0.188
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls		

*See note on page 86.



ANGLES

ELEMENTS OF SECTIONS

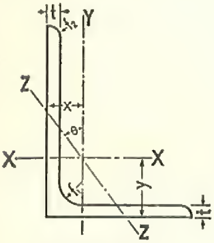
All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.[4]

S = Section Modulus in in.[3]
r = Radius of Gyration in inches.
J = Torsion Factor in in.[4]

Size	Legs	2½ x 2½							3 x 1½
	t	1/8*	3/16*	1/4*	5/16*	3/8*	7/16	1/2	1/4
	Weight	0.75	1.10	1.45	1.78	2.11	2.42	2.73	1.30
	Area	0.62	0.91	1.19	1.47	1.74	2.00	2.26	1.08
	f_1	1/4	1/4	1/4	1/4	1/4	1/4	1/4	5/16
	f_2	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8
Axis X-X	I	0.37	0.54	0.69	0.84	0.98	1.10	1.22	0.98
	S	0.20	0.30	0.39	0.48	0.56	0.64	0.72	0.51
	r	0.77	0.77	0.76	0.76	0.75	0.74	0.73	0.95
	y	0.65	0.68	0.71	0.73	0.76	0.78	0.80	1.08
Axis Y-Y	I	0.37	0.54	0.69	0.84	0.98	1.10	1.22	0.16
	S	0.20	0.30	0.39	0.48	0.56	0.64	0.72	0.14
	r	0.77	0.77	0.76	0.76	0.75	0.74	0.73	0.39
	x	0.65	0.68	0.71	0.73	0.76	0.78	0.80	0.34
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	14° 22′
	I	0.15	0.22	0.29	0.35	0.41	0.47	0.53	0.11
	r	0.50	0.49	0.49	0.49	0.48	0.48	0.48	0.32
	J	0.0033	0.011	0.026	0.051	0.088	0.140	0.208	0.023
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls	77-N		734-L

Size	Legs	3 x 2						3 x 2½				
	t	3/16*	1/4*	5/16*	3/8*	7/16*	1/2	1/4*	5/16*	3/8*	7/16	1/2
	Weight	1.10	1.44	1.78	2.11	2.42	2.73	1.58	1.95	2.32	2.67	3.02
	Area	0.91	1.19	1.47	1.74	2.00	2.26	1.31	1.62	1.92	2.21	2.49
	f_1	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
	f_2	3/16	3/16	3/16	3/16	3/16	3/16	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	0.82	1.06	1.29	1.51	1.71	1.90	1.12	1.37	1.60	1.82	2.03
	S	0.40	0.52	0.65	0.76	0.88	0.99	0.53	0.66	0.78	0.90	1.01
	r	0.95	0.94	0.94	0.93	0.92	0.92	0.92	0.92	0.91	0.91	0.90
	y	0.94	0.97	1.00	1.03	1.05	1.07	0.89	0.92	0.94	0.97	0.99
Axis Y-Y	I	0.29	0.38	0.45	0.53	0.59	0.66	0.70	0.86	1.00	1.14	1.26
	S	0.19	0.25	0.30	0.36	0.41	0.46	0.38	0.47	0.55	0.64	0.72
	r	0.56	0.56	0.56	0.55	0.55	0.54	0.73	0.73	0.72	0.72	0.71
	x	0.46	0.48	0.51	0.53	0.56	0.58	0.64	0.67	0.69	0.72	0.74
Axis Z-Z	Θ	23° 25′	23° 22′	23° 13′	23° 0′	22° 44′	22° 25′	34°03′	34° 0′	33°54′	33°46′	33°37′
	I	0.17	0.22	0.27	0.31	0.36	0.40	0.35	0.43	0.51	0.58	0.65
	r	0.43	0.43	0.43	0.42	0.42	0.42	0.52	0.51	0.51	0.51	0.51
	J	0.011	0.026	0.051	0.088	0.140	0.208	0.029	0.056	0.097	0.154	0.229
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls		734-J	734-ZZ	734-C		

*See note on page 86.



ANGLES

ELEMENTS OF SECTIONS

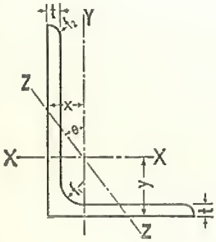
All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.
J=Torsion Factor in in.^{4}

Size	Legs	3 x 3							
	t	3/16*	1/4*	5/16*	3/8*	7/16*[1]	1/2*[2]	9/16	5/8
	Weight	1.33	1.73	2.14	2.55	2.94	3.32	3.69	4.06
	Area	1.10	1.43	1.77	2.10	2.43	2.74	3.05	3.35
	f_1	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
	f_2	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	0.93	1.18	1.45	1.70	1.94	2.16	2.37	2.57
	S	0.42	0.54	0.67	0.80	0.92	1.04	1.15	1.26
	r	0.92	0.91	0.91	0.90	0.89	0.89	0.88	0.88
	y	0.80	0.82	0.85	0.87	0.90	0.92	0.94	0.97
Axis Y-Y	I	0.93	1.18	1.45	1.70	1.94	2.16	2.37	2.57
	S	0.42	0.54	0.67	0.80	0.92	1.04	1.15	1.26
	r	0.92	0.91	0.91	0.90	0.89	0.89	0.88	0.88
	x	0.80	0.82	0.85	0.87	0.90	0.92	0.94	0.97
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.38	0.49	0.60	0.70	0.81	0.91	1.01	1.12
	r	0.59	0.58	0.58	0.58	0.58	0.58	0.58	0.58
	J	0.013	0.031	0.061	0.105	0.167	0.250	0.356	0.488
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls		

[1]Nominal rolled size in this thickness is 3 3/32"x3 3/32"x7/16".
[2]Nominal rolled size in this thickness is 3 5/32"x3 5/32"x1/2".

Size	Legs	3½ x 2½					3½ x 3				
	t	1/4*	5/16*	3/8*	7/16	1/2*	1/4*	5/16*	3/8*	7/16	1/2*
	Weight	1.73	2.14	2.55	2.94	3.32	1.89	2.34	2.78	3.21	3.63
	Area	1.43	1.77	2.10	2.43	2.74	1.57	1.94	2.30	2.66	3.00
	f_1	5/16	5/16	5/16	5/16	5/16	3/8	3/8	3/8	3/8	3/8
	f_2	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	1.73	2.12	2.49	2.84	3.17	1.84	2.26	2.65	3.03	3.38
	S	0.72	0.89	1.06	1.22	1.37	0.74	0.92	1.09	1.26	1.42
	r	1.10	1.09	1.09	1.08	1.08	1.08	1.08	1.07	1.07	1.06
	y	1.09	1.12	1.14	1.17	1.19	1.01	1.04	1.06	1.09	1.11
Axis Y-Y	I	0.73	0.89	1.05	1.19	1.32	1.28	1.52	1.79	2.04	2.27
	S	0.38	0.48	0.57	0.65	0.73	0.57	0.69	0.82	0.94	1.06
	r	0.71	0.71	0.71	0.70	0.69	0.90	0.89	0.88	0.88	0.87
	x	0.60	0.62	0.65	0.67	0.70	0.76	0.79	0.82	0.84	0.86
Axis Z-Z	Θ	26° 23′	26° 18′	26° 10′	26° 0′	25° 48′	36° 13′	35° 40′	35° 37′	35° 32′	35° 26′
	I	0.41	0.50	0.59	0.67	0.76	0.63	0.74	0.87	1.00	1.13
	r	0.53	0.53	0.53	0.53	0.53	0.63	0.62	0.62	0.61	0.61
	J	0.031	0.061	0.105	0.167	0.250	0.034	0.066	0.114	0.181	0.271
	Tools	734-D	734-UU	734-24		734-23	734-BB	734-22	734-27	734-39	734-NN

*See note on page 86.



ANGLES

ELEMENTS OF SECTIONS

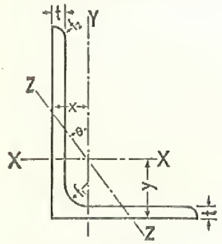
All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.[4]

S=Section Modulus in in.[3]
r=Radius of Gyration in inches.
J=Torsion Factor in in.[4]

Size	Legs	3½ x 3½						
	t	¼*	5/16*	3/8*	7/16	½*	9/16	5/8
	Weight	2.05	2.53	3.01	3.48	3.94	4.39	4.83
	Area	1.69	2.09	2.49	2.87	3.25	3.62	3.99
	f_1	3/8	3/8	3/8	3/8	3/8	3/8	3/8
	f_2	¼	¼	¼	¼	¼	¼	¼
Axis X-X	I	1.93	2.37	2.79	3.18	3.56	3.92	4.26
	S	0.76	0.94	1.11	1.28	1.45	1.61	1.77
	r	1.07	1.06	1.06	1.05	1.05	1.04	1.03
	y	0.94	0.97	1.00	1.02	1.05	1.07	1.09
Axis Y-Y	I	1.93	2.37	2.79	3.18	3.56	3.92	4.26
	S	0.76	0.94	1.11	1.28	1.45	1.61	1.77
	r	1.07	1.06	1.06	1.05	1.05	1.04	1.03
	x	0.94	0.97	1.00	1.02	1.05	1.07	1.09
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	0.80	0.98	1.15	1.32	1.49	1.65	1.81
	r	0.69	0.68	0.68	0.68	0.68	0.67	0.67
	J	0.036	0.071	0.123	0.195	0.292	0.415	0.570
	Tools	78-G	78-CC	78-GG		77-Z		

Size	Legs	4 x 3							4 x 3½			
	t	¼*	5/16*	3/8*	7/16*	½*	9/16	5/8*	5/16	3/8*	7/16	½*
	Weight	2.05	2.53	3.01	3.48	3.94	4.39	4.83	2.70	3.22	3.72	4.22
	Area	1.69	2.09	2.49	2.87	3.25	3.62	3.99	2.23	2.66	3.08	3.49
	f_1	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8
	f_2	¼	¼	¼	¼	¼	¼	¼	5/16	5/16	5/16	5/16
Axis X-X	I	2.68	3.29	3.88	4.43	4.96	5.47	5.95	3.40	4.02	4.61	5.17
	S	0.96	1.19	1.42	1.63	1.85	2.05	2.25	1.19	1.43	1.65	1.87
	r	1.26	1.25	1.25	1.24	1.24	1.23	1.22	1.23	1.23	1.22	1.22
	y	1.21	1.24	1.26	1.29	1.31	1.34	1.36	1.15	1.18	1.21	1.23
Axis Y-Y	I	1.29	1.58	1.86	2.12	2.36	2.60	2.82	2.42	2.85	3.27	3.67
	S	0.56	0.70	0.83	0.96	1.08	1.20	1.32	0.93	1.11	1.29	1.46
	r	0.87	0.87	0.86	0.86	0.85	0.85	0.84	1.04	1.04	1.03	1.03
	x	0.72	0.74	0.77	0.79	0.82	0.84	0.86	0.91	0.94	0.96	0.99
Axis Z-Z	Θ	28° 42′	28° 40′	28° 35′	28° 28′	28° 20′	28° 11′	28° 0′	36° 54′	36° 53′	36° 50′	36° 46′
	I	0.70	0.85	1.01	1.15	1.30	1.44	1.58	1.15	1.36	1.57	1.77
	r	0.64	0.64	0.64	0.63	0.63	0.63	0.63	0.72	0.72	0.71	0.71
	J	0.036	0.071	0.123	0.195	0.292	0.415	0.570	0.076	0.132	0.209	0.313
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls		Rolls		734-AA		734-30

*See note on page 86.



ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}

S=Section Modulus in in.^{3}
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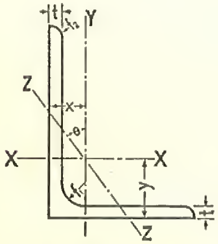
J=Torsion Factor in in.^{4}

Size	Legs	4 x 4								
	t	1/4*	5/16*	3/8*	7/16*	1/2*	9/16*	5/8*	11/16*[1]	3/4*[2]
Weight		2.35	2.91	3.46	4.01	4.54	5.07	5.58	6.09	6.58
Area		1.94	2.41	2.86	3.31	3.75	4.19	4.61	5.03	5.44
f_1		3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8	3/8
f_2		1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	2.94	3.61	4.26	4.87	5.46	6.02	6.56	7.08	7.57
	S	1.00	1.24	1.48	1.71	1.93	2.15	2.36	2.57	2.77
	r	1.23	1.23	1.22	1.21	1.21	1.20	1.19	1.19	1.18
	y	1.07	1.10	1.12	1.15	1.17	1.20	1.22	1.24	1.26
Axis Y-Y	I	2.94	3.61	4.26	4.87	5.46	6.02	6.56	7.08	7.57
	S	1.00	1.24	1.48	1.71	1.93	2.15	2.36	2.57	2.77
	r	1.23	1.23	1.22	1.21	1.21	1.20	1.19	1.19	1.18
	x	1.07	1.10	1.12	1.15	1.17	1.20	1.22	1.24	1.26
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	1.21	1.48	1.75	2.01	2.26	2.51	2.76	3.00	3.25
	r	0.79	0.78	0.78	0.78	0.78	0.77	0.77	0.77	0.77
J		0.042	0.081	0.141	0.223	0.333	0.475	0.651	0.867	1.125
Tools		Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls	Rolls

[1]Nominal rolled size in this thickness is 4 3/16″x4 3/16″x11/16″.
[2]Nominal rolled size in this thickness is 4 1/4″x4 1/4″x3/4″.

Size	Legs	5 x 2 1/2	5 x 3		5 x 3 1/2					
	t	1/2	3/8*	1/2*	5/16*	3/8*	7/16*	1/2*	9/16	5/8*
Weight		4.24	3.45	4.52	3.09	3.69	4.27	4.84	5.40	5.95
Area		3.50	2.85	3.74	2.56	3.05	3.53	4.00	4.46	4.92
f_1		3/8	3/8	3/8	7/16	7/16	7/16	7/16	7/16	7/16
f_2		1/4	5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
Axis X-X	I	8.74	7.15	9.24	6.39	7.56	8.69	9.77	10.82	11.82
	S	2.77	2.15	2.83	1.85	2.21	2.56	2.90	3.24	3.56
	r	1.58	1.59	1.57	1.58	1.58	1.57	1.56	1.56	1.55
	y	1.84	1.68	1.73	1.55	1.58	1.61	1.63	1.66	1.68
Axis Y-Y	I	1.46	1.93	2.48	2.58	3.04	3.49	3.91	4.32	4.70
	S	0.77	0.84	1.10	0.96	1.15	1.33	1.50	1.67	1.84
	r	0.64	0.82	0.81	1.00	1.00	0.99	0.99	0.98	0.98
	x	0.60	0.69	0.74	0.81	0.84	0.87	0.89	0.92	0.94
Axis Z-Z	Θ	14° 12′	19° 40′	19° 26′	25° 33′	25° 32′	25° 27′	25° 22′	25° 15′	25° 07′
	I	0.96	1.17	1.52	1.45	1.71	1.97	2.22	2.46	2.70
	r	0.52	0.64	0.64	0.75	0.75	0.75	0.74	0.74	0.74
J		0.313	0.141	0.333	0.086	0.149	0.237	0.354	0.504	0.692
Tools		734-DD	734-Q	734-38	Rolls	Rolls	Rolls	Rolls		Rolls

*See note on page 86.



ANGLES

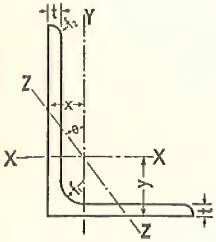
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Legs	5 x 3½	5 x 5						
	t	¾	⅜*	7/16*	½*	9/16	⅝*	11/16	¾
Weight		7.025	4.36	5.05	5.74	6.42	7.08	7.74	8.39
Area		5.806	3.60	4.18	4.74	5.30	5.85	6.40	6.93
f_1		½	½	½	½	½	½	½	½
f_2		⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜
Axis X-X	I	13.619	8.37	9.65	10.89	12.08	13.22	14.33	15.39
	S	4.161	2.30	2.67	3.03	3.39	3.73	4.07	4.41
	r	1.532	1.52	1.52	1.52	1.51	1.50	1.50	1.49
	y	1.727	1.36	1.38	1.41	1.43	1.46	1.48	1.51
Axis Y-Y	I	5.371	8.37	9.65	10.89	12.08	13.22	14.33	15.39
	S	2.135	2.30	2.67	3.03	3.39	3.73	4.07	4.41
	r	0.962	1.52	1.52	1.52	1.51	1.50	1.50	1.49
	x	0.984	1.36	1.38	1.41	1.43	1.46	1.48	1.51
Axis Z-Z	Θ	24° 45′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	3.142	3.44	3.96	4.47	4.97	5.47	5.96	6.44
	r	0.736	0.98	0.97	0.97	0.97	0.97	0.97	0.96
	J	1.195	0.176	0.279	0.417	0.593	0.814	1.08	1.41
Tools		734-33	77-J	78-X	78-RR		78-QQ		

Size	Legs	6 x 3½							
	t	5/16*	⅜*	7/16	½*	9/16	⅝	11/16	¾
Weight		3.49	4.15	4.81	5.46	6.10	6.73	7.35	7.95
Area		2.88	3.43	3.98	4.51	5.04	5.56	6.07	6.57
f_1		½	½	½	½	½	½	½	½
f_2		5/16	5/16	5/16	5/16	5/16	5/16	5/16	5/16
Axis X-X	I	10.64	12.60	14.50	16.34	18.11	19.83	21.49	23.09
	S	2.64	3.15	3.65	4.14	4.62	5.09	5.56	6.01
	r	1.92	1.92	1.91	1.90	1.90	1.89	1.88	1.87
	y	1.97	2.00	2.03	2.06	2.08	2.11	2.13	2.16
Axis Y-Y	I	2.70	3.19	3.66	4.11	4.53	4.94	5.33	5.71
	S	0.98	1.17	1.35	1.53	1.71	1.88	2.05	2.21
	r	0.97	0.96	0.96	0.95	0.95	0.94	0.94	0.93
	x	0.74	0.77	0.80	0.82	0.85	0.87	0.89	0.92
Axis Z-Z	Θ	18° 52′	18° 51′	18° 47′	18° 42′	18° 35′	18° 28′	18° 20′	18° 11′
	I	1.65	1.95	2.24	2.52	2.80	3.07	3.34	3.61
	r	0.76	0.75	0.75	0.75	0.75	0.74	0.74	0.74
	J	0.097	0.167	0.265	0.396	0.564	0.773	1.03	1.34
Tools		734-35	734-R		734-9		734-26		

*See note on page 86.



ANGLES

ELEMENTS OF SECTIONS

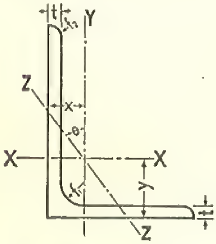
All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.[4]
S=Section Modulus in in.[3]
r=Radius of Gyration in inches.
J=Torsion Factor in in.[4]

Size	Legs	6 x 4						
	t	3/8*	7/16*	1/2*	9/16*	5/8*	11/16	3/4*[1]
	Weight	4.36	5.05	5.74	6.42	7.08	7.74	8.39
	Area	3.60	4.18	4.74	5.30	5.85	6.40	6.93
	f_1	1/2	1/2	1/2	1/2	1/2	1/2	1/2
	f_2	3/8	3/8	3/8	3/8	3/8	3/8	3/8
Axis X-X	I	13.02	15.02	16.95	18.82	20.63	22.39	24.08
	S	3.17	3.69	4.19	4.69	5.17	5.64	6.11
	r	1.90	1.90	1.89	1.88	1.88	1.87	1.86
	y	1.90	1.93	1.96	1.98	2.01	2.03	2.06
Axis Y-Y	I	4.63	5.34	6.01	6.65	7.27	7.86	8.43
	S	1.50	1.74	1.98	2.21	2.44	2.66	2.87
	r	1.13	1.13	1.13	1.12	1.11	1.11	1.10
	x	0.91	0.94	0.97	0.99	1.02	1.04	1.07
Axis Z-Z	Θ	23° 33′	23° 31′	23° 27′	23° 22′	23° 16′	23° 10′	23° 02′
	I	2.67	3.07	3.47	3.86	4.24	4.61	4.98
	r	0.86	0.86	0.86	0.85	0.85	0.85	0.85
	J	0.176	0.279	0.417	0.593	0.814	1.08	1.41
	Tools	Rolls	Rolls	Rolls	Rolls	Rolls		Rolls

[1]Nominal rolled size in this thickness is 6 3/16"x4 3/16"x3/4".

Size	Legs	6 x 6						
	t	3/8*	7/16*	1/2*	9/16	5/8*	11/16	3/4
	Weight	5.27	6.11	6.95	7.78	8.59	9.40	10.20
	Area	4.35	5.05	5.74	6.43	7.10	7.77	8.43
	f_1	1/2	1/2	1/2	1/2	1/2	1/2	1/2
	f_2	3/8	3/8	3/8	3/8	3/8	3/8	3/8
Axis X-X	I	14.85	17.15	19.38	21.54	23.64	25.67	27.64
	S	3.38	3.93	4.46	4.99	5.51	6.02	6.52
	r	1.85	1.84	1.84	1.83	1.82	1.82	1.81
	y	1.60	1.63	1.66	1.68	1.71	1.73	1.76
Axis Y-Y	I	14.85	17.15	19.38	21.54	23.64	25.67	27.64
	S	3.38	3.93	4.46	4.99	5.51	6.02	6.52
	r	1.85	1.84	1.84	1.83	1.82	1.82	1.81
	x	1.60	1.63	1.66	1.68	1.71	1.73	1.76
Axis Z-Z	Θ	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′	45° 0′
	I	6.07	7.01	7.92	8.82	9.70	10.57	11.43
	r	1.18	1.18	1.17	1.17	1.17	1.17	1.16
	J	0.211	0.335	0.500	0.712	0.977	1.30	1.69
	Tools	78-Q	78-V	78-S		78-HH	78-W	

*See note on page 86.



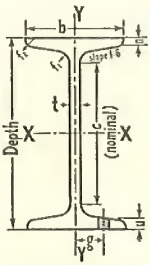
ANGLES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.[4]
S=Section Modulus in in.[3]
r=Radius of Gyration in inches.
J=Torsion Factor in in.[4]

Size	Legs	8 x 6			8 x 8		
	t	5/8*	11/16*	3/4*	1/2*	3/4*	1*
	Weight	10.129	11.07	12.016	9.41	13.87	18.18
	Area	8.371	9.15	9.931	7.77	11.46	15.02
	f_1	1/2	1/2	·1/2	5/8	5/8	5/8
	f_2	5/16	3/8	3/8	3/8	3/8	3/8
Axis X-X	I	53.571	57.99	62.603	47.74	68.86	88.11
	S	9.737	10.58	11.474	8.16	11.99	15.60
	r	2.530	2.52	2.511	2.48	2.45	2.42
	y	2.498	2.52	2.544	2.15	2.26	2.35
Axis Y-Y	I	25.939	27.98	30.150	47.74	68.86	88.11
	S	5.770	6.25	6.774	8.16	11.99	15.60
	r	1.760	1.75	1.742	2.48	2.45	2.42
	x	1.504	1.53	1.549	2.15	2.26	2.35
Axis Z-Z	Θ	28° 52′	28° 47′	28° 43′	45° 0′	45° 0′	45° 0′
	I	13.891	15.02	16.236	19.51	28.20	36.46
	r	1.288	1.28	1.279	1.58	1.57	1.56
	J	1.139	1.516	1.969	0.667	2.25	5.33
	Tools	734-34	734-37	734-32	78-SS		

*See note on page 86.



STANDARD I-BEAMS

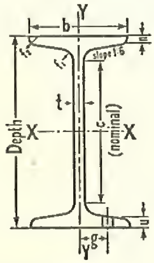
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	3			4			
	t	0.170*	0.251	0.349*	0.190*	0.253	0.326*	0.400
	Weight	2.02	2.31	2.67	2.72	3.03	3.38	3.74
	Area	1.67	1.91	2.21	2.25	2.50	2.79	3.09
	b	2.330	2.411	2.509	2.660	2.723	2.796	2.870
	n	0.170	0.170	0.170	0.190	0.190	0.190	0.190
	f_1	0.27	0.27	0.27	0.29	0.29	0.29	0.29
	f_2	0.10	0.10	0.10	0.11	0.11	0.11	0.11
	c	1¾	1¾	1¾	2¾	2¾	2¾	2¾
Axis X-X	I	2.52	2.71	2.93	6.06	6.40	6.79	7.18
	S	1.68	1.80	1.95	3.03	3.20	3.39	3.59
	r	1.23	1.19	1.15	1.64	1.60	1.56	1.52
Axis Y-Y	I	0.46	0.51	0.59	0.76	0.82	0.90	0.99
	S	0.39	0.42	0.47	0.57	0.61	0.65	0.69
	r	0.52	0.52	0.52	0.58	0.57	0.57	0.57
Rivet Data	Diam.	⅜	⅜	⅜	½	½	½	½
	g	¾	¾	¾	¾	¾	¾	¾
	u	5/16	5/16	5/16	5/16	5/16	5/16	5/16
	J	0.045	0.061	0.093	0.074	0.092	0.12	0.17
	Tools	Rolls	851-J	Rolls	Rolls		Rolls	

Size	Depth	5			6			7		
	t	0.210*	0.347	0.494*	0.230*	0.343*	0.465	0.250	0.345*	0.450
	Weight	3.53	4.36	5.25	4.43	5.25	6.13	5.42	6.23	7.12
	Area	2.92	3.60	4.34	3.66	4.34	5.07	4.48	5.15	5.88
	b	3.000	3.137	3.284	3.330	3.443	3.565	3.660	3.755	3.860
	n	0.210	0.210	0.210	0.230	0.230	0.230	0.250	0.250	0.250
	f_1	0.31	0.31	0.31	0.33	0.33	0.33	0.35	0.35	0.35
	f_2	0.13	0.13	0.13	0.14	0.14	0.14	0.15	0.15	0.15
	c	3½	3½	3½	4½	4½	4½	5¼	5¼	5¼
Axis X-X	I	12.26	13.69	15.22	22.08	24.11	26.31	36.69	39.40	42.40
	S	4.90	5.48	6.09	7.36	8.04	8.77	10.48	11.26	12.12
	r	2.05	1.95	1.87	2.46	2.36	2.28	2.86	2.77	2.69
Axis Y-Y	I	1.21	1.41	1.66	1.82	2.04	2.31	2.63	2.88	3.17
	S	0.81	0.90	1.01	1.09	1.19	1.30	1.44	1.53	1.64
	r	0.64	0.63	0.62	0.71	0.69	0.68	0.77	0.75	0.73
Rivet Data	Diam.	½	½	½	⅝	⅝	⅝	⅝	⅝	⅝
	g	⅞	⅞	⅞	1	1	1	1⅛	1⅛	1⅛
	u	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜	⅜
	J	0.12	0.19	0.33	0.17	0.24	0.38	0.25	0.32	0.46
	Tools	851-C	851-E	851-O	851-K	851-L	851-S		851-H	

*See note on page 86.



STANDARD I-BEAMS

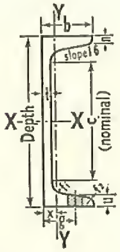
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.
J=Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g=Usual gage.
u=Nominal grip.

Size		8				9		
	Depth	8				9		
	t	0.270*	0.349	0.441	0.532*	0.290	0.397	0.561
	Weight	6.53	7.30	8.19	9.07	7.72	8.89	10.68
	Area	5.40	6.03	6.77	7.49	6.38	7.35	8.82
	b	4.000	4.079	4.171	4.262	4.330	4.437	4.601
	n	0.270	0.270	0.270	0.270	0.290	0.290	0.290
	f_1	0.37	0.37	0.37	0.37	0.39	0.39	0.39
	f_2	0.16	0.16	0.16	0.16	0.17	0.17	0.17
	c	6 1/4	6 1/4	6 1/4	6 1/4	7	7	7
Axis X-X	I	57.55	60.92	64.85	68.73	85.90	92.40	102.36
	S	14.39	15.23	16.21	17.18	19.09	20.53	22.75
	r	3.27	3.18	3.10	3.03	3.67	3.55	3.41
Axis Y-Y	I	3.73	3.99	4.31	4.66	5.09	5.54	6.30
	S	1.86	1.95	2.07	2.19	2.35	2.50	2.74
	r	0.83	0.81	0.80	0.79	0.89	0.87	0.85
Rivet Data	Diam.	3/4	3/4	3/4	3/4	3/4	3/4	3/4
	g	1 1/8	1 1/8	1 1/8	1 1/8	1 1/4	1 1/4	1 1/4
	u	7/16	7/16	7/16	1/2	1/2	1/2	1/2
	J	0.34	0.42	0.56	0.75	0.46	0.61	0.99
	Tools	851-G			851-M	851-N		

Size		10			12				
	Depth	10			12				
	t	0.310*	0.447	0.594	0.350*	0.428	0.460	0.565	0.687
	Weight	9.01	10.67	12.45	11.31	12.44	14.49	16.01	17.78
	Area	7.45	8.82	10.29	9.35	10.28	11.97	13.23	14.70
	b	4.660	4.797	4.944	5 000	5.078	5.250	5.355	5.477
	n	0.310	0.310	0.310	0.350	0.350	0.460	0.460	0.460
	f_1	0.41	0.41	0.41	0.45	0.45	0.56	0.56	0.56
	f_2	0.19	0.19	0.19	0.21	0.21	0.28	0.28	0.28
	c	8	8	8	9 3/4	9 3/4	9 1/4	9 1/4	9 1/4
Axis X-X	I	123.39	134.81	147.06	218.13	229.36	272.15	287.27	304.84
	S	24.68	26.96	29.41	36.35	38.23	45.36	47.88	50.81
	r	4.07	3.91	3.78	4.83	4.72	4.77	4.66	4.56
Axis Y-Y	I	6.78	7.50	8.36	9.35	9.87	13.54	14.50	15.71
	S	2.91	3.13	3.38	3.74	3.89	5.16	5.42	5.74
	r	0.95	0.92	0.90	1.00	0.98	1.06	1.05	1.03
Rivet Data	Diam.	3/4	3/4	3/4	3/4	3/4	3/4	3/4	3/4
	g	1 3/8	1 3/8	1 3/8	1 1/2	1 1/2	1 1/2	1 1/2	1 3/4
	u	1/2	1/2	1/2	9/16	9/16	3/4	3/4	3/4
	J	0.62	0.86	1.31	0.92	1.10	1.78	2.19	2.85
	Tools	851-P	851-V	851-R	851-T		851-U	851-Q	

*See note on page 86.



STANDARD CHANNELS

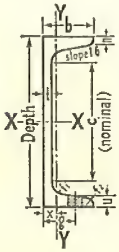
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	3					4		
	t	0.170*	0.187	0.258*	0.320	0.356*	0.180*	0.247*	0.320*
	Weight	1.46	1.52	1.78	2.00	2.13	1.90	2.22	2.58
	Area	1.21	1.26	1.47	1.66	1.76	1.57	1.84	2.13
	b	1.410	1.427	1.498	1.560	1.596	1.580	1.647	1.720
	n	0.170	0.170	0.170	0.170	0.170	0.180	0.180	0.180
	f_1	0.27	0.27	0.27	0.27	0.27	0.28	0.28	0.28
	f_2	0.10	0.10	0.10	0.10	0.10	0.11	0.11	0.11
	c	1¾	1¾	1¾	1¾	1¾	2¾	2¾	2¾
Axis X-X	I	1.66	1.69	1.85	1.99	2.07	3.83	4.19	4.58
	S	1.10	1.13	1.24	1.33	1.38	1.92	2.10	2.29
	r	1.17	1.16	1.12	1.10	1.08	1.56	1.51	1.47
Axis Y-Y	I	0.20	0.21	0.25	0.28	0.31	0.32	0.37	0.43
	S	0.20	0.21	0.23	0.25	0.27	0.28	0.31	0.34
	r	0.40	0.41	0.41	0.41	0.42	0.45	0.45	0.45
	x	0.44	0.44	0.44	0.45	0.46	0.46	0.45	0.46
Rivet Data	Diam.	½	½	½	½	½	½	½	½
	g	⅞	⅞	⅞	⅞	⅞	1	1	1
	u	¼	¼	¼	¼	¼	5/16	5/16	5/16
	J	0.031	0.033	0.047	0.066	0.080	0.045	0.062	0.090
	Tools	Rolls	852-Z	Rolls	852-AB	Rolls	Rolls	Rolls	Rolls

Size	Depth	5				6			
	t	0.190*	0.225	0.325*	0.472*	0.200*	0.225*	0.314*	0.437*
	Weight	2.38	2.59	3.20	4.09	2.91	3.09	3.73	4.63
	Area	1.97	2.14	2.64	3.38	2.40	2.55	3.09	3.82
	b	1.750	1.785	1.885	2.032	1.920	1.945	2.034	2.157
	n	0.190	0.190	0.190	0.190	0.200	0.200	0.200	0.200
	f_1	0.29	0.29	0.29	0.29	0.30	0.30	0.30	0.30
	f_2	0.11	0.11	0.11	0.11	0.12	0.12	0.12	0.12
	c	3¾	3¾	3¾	3¾	4½	4½	4½	4½
Axis X-X	I	7.49	7.86	8.90	10.43	13.12	13.57	15.18	17.39
	S	3.00	3.14	3.56	4.17	4.37	4.52	5.06	5.80
	r	1.95	1.91	1.83	1.76	2.34	2.31	2.22	2.13
Axis Y-Y	I	0.48	0.52	0.63	0.81	0.69	0.73	0.87	1.05
	S	0.38	0.40	0.45	0.53	0.49	0.51	0.56	0.64
	r	0.49	0.49	0.49	0.49	0.54	0.54	0.53	0.52
	x	0.48	0.48	0.48	0.51	0.51	0.51	0.50	0.51
Rivet Data	Diam.	½	½	½	½	⅝	⅝	⅝	⅝
	g	1⅛	1⅛	1⅛	1⅛	1⅛	1⅛	1⅛	1⅜
	u	5/16	5/16	5/16	5/16	5/16	5/16	⅜	⅜
	J	0.064	0.074	0.12	0.25	0.088	0.097	0.14	0.26
	Tools	Rolls		Rolls	Rolls	Rolls	Rolls	Rolls	Rolls

*See note on page 86.



STANDARD CHANNELS

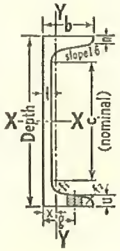
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	7					8				
	t	0.210	0.230*	0.314*	0.419*	0.524	0.250*	0.303*	0.395*	0.487*	0.520
Weight		3.47	3.64	4.36	5.24	6.13	4.38	4.89	5.78	6.67	6.99
Area		2.87	3.01	3.60	4.33	5.07	3.62	4.04	4.78	5.51	5.78
	b	2.090	2.110	2.194	2.299	2.404	2.290	2.343	2.435	2.527	2.560
	n	0.210	0.210	0.210	0.210	0.210	0.220	0.220	0.220	0.220	0.220
	f_1	0.31	0.31	0.31	0.31	0.31	0.32	0.32	0.32	0.32	0.32
	f_2	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
	c	5½	5½	5½	5½	5½	6½	6¼	6¼	6¼	6¼
Axis X-X	I	21.27	21.84	24.24	27.24	30.25	33.85	36.11	40.04	43.96	45.37
	S	6.08	6.24	6.93	7.78	8.64	8.46	9.03	10.01	10.99	11.34
	r	2.72	2.69	2.60	2.51	2.44	3.06	2.99	2.90	2.82	2.80
Axis Y-Y	I	0.97	1.01	1.17	1.38	1.59	1.40	1.53	1.75	1.98	2.07
	S	0.63	0.64	0.70	0.78	0.86	0.81	0.85	0.93	1.01	1.04
	r	0.58	0.58	0.57	0.56	0.56	0.62	0.61	0.61	0.60	0.60
	x	0.54	0.54	0.52	0.53	0.55	0.56	0.55	0.55	0.57	0.57
Rivet Data	Diam.	⅝	⅝	⅝	⅝	⅝	¾	¾	¾	¾	¾
	g	1¼	1¼	1¼	1¼	1½	1⅜	1⅜	1½	1½	1½
	u	⅜	7/16	⅜	7/16	7/16	⅜	⅜	7/16	7/16	7/16
J		0.12	0.13	0.18	0.29	0.47	0.17	0.21	0.32	0.47	0.55
Tools			Rolls	Rolls	Rolls	852-Q	Rolls	Rolls	Rolls	Rolls	

Size	Depth	9				10			
	t	0.230*	0.285	0.448*	0.612	0.240*	0.379	0.526*	0.673
Weight		4.74	5.34	7.11	8.90	5.43	7.11	8.89	10.67
Area		3.91	4.41	5.88	7.35	4.49	5.88	7.35	8.82
	b	2.430	2.485	2.648	2.812	2.600	2.739	2.886	3.033
	n	0.230	0.230	0.230	0.230	0.240	0.240	0.240	0.240
	f_1	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.34
	f_2	0.14	0.14	0.14	0.14	0.14	0.14	0.14	0.14
	c	7¼	7¼	7¼	7¼	8¼	8¼	8¼	8¼
Axis X-X	I	47.68	51.02	60.92	70.89	67.37	78.95	91.20	103.45
	S	10.60	11.34	13.54	15.75	13.47	15.79	18.24	20.69
	r	3.49	3.40	3.22	3.11	3.87	3.66	3.52	3.43
Axis Y-Y	I	1.75	1.93	2.42	2.94	2.28	2.81	3.36	3.95
	S	0.96	1.01	1.17	1.34	1.16	1.32	1.48	1.66
	r	0.67	0.66	0.64	0.63	0.71	0.69	0.68	0.67
	x	0.60	0.59	0.58	0.61	0.63	0.61	0.62	0.65
Rivet Data	Diam.	¾	¾	¾	¾	¾	¾	¾	¾
	g	1⅜	1⅜	1½	1½	1½	1½	1¾	1¾
	u	7/16	7/16	½	½	7/16	7/16	½	½
J		0.20	0.24	0.47	0.92	0.25	0.41	0.75	1.32
Tools		852-R		852-T	852-U	852-P		852-AE	

*See note on page 86.



STANDARD CHANNELS

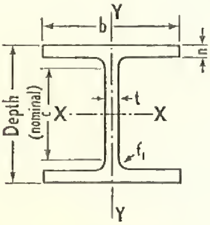
ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

J = Torsion Factor in in.^{4}
Rivet given is maximum allowable in flange.
g = Usual gage.
u = Nominal grip.

Size	Depth	12				15	
	t	0.300*	0.387*	0.510*	0.632	0.400*	0.716*
	Weight	7.63	8.89	10.67	12.45	12.05	17.78
	Area	6.30	7.35	8.82	10.29	9.96	14.70
	b	2.960	3.047	3.170	3.292	3.400	3.716
	n	0.280	0.280	0.280	0.280	0.400	0.400
	f_1	0.38	0.38	0.38	0.38	0.500	0.500
	f_2	0.17	0.17	0.17	0.17	0.240	0.240
	c	10	10	10	10	12⅜	12⅜
Axis X-X	I	131.84	144.37	162.08	179.65	314.76	403.64
	S	21.97	24.06	27.01	29.94	41.97	53.82
	r	4.57	4.43	4.29	4.18	5.62	5.24
Axis Y-Y	I	3.99	4.47	5.14	5.82	9.63	12.53
	S	1.76	1.89	2.06	2.24	3.11	4.30
	r	0.80	0.78	0.76	0.75	0.90	0.92
	x	0.69	0.67	0.67	0.69	0.79	0.80
Rivet Data	Diam.	⅞	⅞	⅞	⅞	1	1
	g	1¾	1¾	1¾	2	2	2
	u	½	½	½	⅝	⅝	⅝
	J	0.46	0.61	0.95	1.48	1.17	2.89
	Tools	Rolls	Rolls	Rolls	852-O	852-AC	

*See note on page 86.



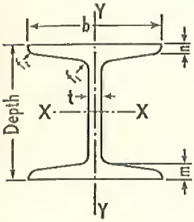
WIDE-FLANGE BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.
J=Torsion Factor in in.^{4}

		Nominal Size	6 x 4	6 x 6	8 x 5	8 x 7	8 x 8	10 x 5¾
		Actual Depth	6.00*	6.00*	8.00*	8.00*	8.00*	9.90*
		t	0.230	0.240	0.230	0.245	0.288	0.240
		Weight	4.28	5.56	6.07	8.56	11.04	7.51
		Area	3.54	4.59	5.02	7.08	9.12	6.21
		b	4.00	6.00	5.25	6.50	8.00	5.75
		n	0.279	0.269	0.308	0.398	0.433	0.340
		f_1	0.250	0.250	0.320	0.400	0.400	0.312
		c	4⅞	4⅞	6¾	6⅜	6⅜	8½
Axis X-X		I	21.75	30.17	56.73	84.15	109.66	106.74
		S	7.25	10.06	14.18	21.04	27.41	21.56
		r	2.48	2.56	3.36	3.45	3.47	4.15
Axis Y-Y		I	2.98	9.69	7.44	18.23	36.97	10.77
		S	1.49	3.23	2.83	5.61	9.24	3.75
		r	0.92	1.45	1.22	1.61	2.01	1.32
		J	0.082	0.106	0.135	0.312	0.497	0.196
		Tools	42100-D	42100-H	42100-E	42100-F	42100-G	42100-J

*See note on page 86.



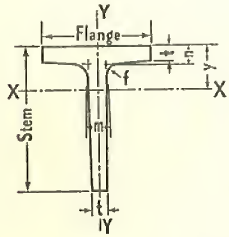
H-BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.
J=Torsion Factor in in.^{4}

Size	Depth	4	5	6			8		
	t	0.313*	0.313*	0.250*	0.313	0.438	0.313*	0.375	0.500*
Weight		4.85	6.63	8.04	8.49	9.40	11.51	12.11	13.32
Area		4.00	5.48	6.64	7.02	7.77	9.52	10.01	11.01
b		4.000	5.000	5.938	6.000	6.125	7.938	8.000	8.125
m		0.453	0.503	0.542	0.542	0.542	0.560	0.560	0.560
n		0.290	0.330	0.360	0.360	0.360	0.358	0.358	0.358
f_1		0.313	0.313	0.313	0.313	0.313	0.313	0.313	0.313
f_2		0.145	0.165	0.180	0.180	0.180	0.179	0.179	0.179
Axis X-X	I	10.72	23.82	44.06	45.19	47.44	112.94	115.58	120.92
	S	5.36	9.53	14.69	15.06	15.81	28.23	28.90	30.23
	r	1.64	2.08	2.58	2.54	2.47	3.45	3.40	3.31
Axis Y-Y	I	3.56	7.82	14.18	14.65	15.65	34.15	35.01	36.79
	S	1.78	3.13	4.77	4.88	5.11	8.60	8.75	9.06
	r	0.94	1.19	1.46	1.44	1.42	1.89	1.87	1.83
J		0.22	0.34	0.45	0.50	0.62	0.68	0.75	0.96
Tools		3002-A	3002-B	3002-C		3002-F	3002-D		3002-E

*See note on page 86.



TEES

ELEMENTS OF SECTIONS

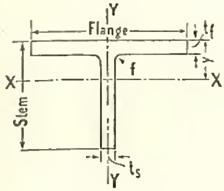
All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

Size	Flange	1	1½					2		2¼	2½		
Size	Stem	1	1¼	1¼	1½	1½	2	2*	2	2¼*	1¼	2½*	3
Size	t	⅛	⅛	3/16	3/16	¼	3/16	¼	5/16	¼	3/16	5/16	5/16
	Weight	0.323	0.451	0.633	0.704	0.895	0.884	1.29	1.55	1.47	1.03	1.97	2.17
	Area	0.267	0.373	0.523	0.581	0.740	0.730	1.07	1.28	1.21	0.85	1.62	1.80
	m	5/32	5/32	7/32	7/32	9/32	¼	5/16	⅜	5/16	5/16	⅜	⅜
	n	5/32	5/32	7/32	7/32	9/32	¼	5/16	⅜	5/16	9/32	⅜	⅜
	f	⅛	⅛	⅛	3/16	3/16	3/16	¼	¼	¼	3/16	¼	¼
Axis X-X	I	0.023	0.049	0.067	0.114	0.142	0.269	0.37	0.43	0.53	0.08	0.89	1.49
Axis X-X	S	0.032	0.053	0.075	0.108	0.137	0.195	0.26	0.31	0.33	0.09	0.50	0.72
Axis X-X	r	0.293	0.363	0.359	0.443	0.438	0.606	0.59	0.58	0.66	0.31	0.74	0.91
Axis X-X	y	0.292	0.326	0.352	0.437	0.464	0.624	0.58	0.61	0.64	0.30	0.73	0.92
Axis Y-Y	I	0.011	0.038	0.056	0.056	0.075	0.060	0.18	0.23	0.26	0.28	0.44	0.44
Axis Y-Y	S	0.023	0.051	0.075	0.075	0.100	0.080	0.18	0.23	0.23	0.22	0.35	0.35
Axis Y-Y	r	0.206	0.319	0.328	0.312	0.319	0.286	0.41	0.42	0.46	0.57	0.52	0.50
	Tools	853-F	853-B	853-N	853-K	853-G	853-W	853-C	853-X	853-J	853-A	853-M	853-P

Size	Flange	3			4							4½	5
Size	Stem	2½	3	3*	2	2½	3	4*	4½	5	5	3	3
Size	t	5/16	5/16	⅜	⅜	5/16	5/16	⅜	⅜	⅜	½	5/16	⅜
	Weight	2.19	2.40	2.79	2.78	2.63	2.84	3.85	4.10	4.34	5.56	3.04	4.14
	Area	1.81	1.98	2.31	2.30	2.17	2.34	3.18	3.39	3.59	4.60	2.52	3.42
	m	⅜	⅜	7/16	7/16	⅜	⅜	7/16	7/16	7/16	9/16	⅜	⅝
	n	⅜	⅜	7/16	7/16	⅜	⅜	7/16	7/16	7/16	9/16	⅜	7/16
	f	5/16	5/16	5/16	¼	⅜	⅜	½	½	½	½	⅜	⅜
Axis X-X	I	0.94	1.58	1.83	0.60	1.01	1.72	4.56	6.37	8.56	10.84	1.78	2.37
Axis X-X	S	0.51	0.74	0.86	0.40	0.53	0.77	1.58	1.98	2.43	3.14	0.78	1.06
Axis X-X	r	0.72	0.89	0.89	0.51	0.68	0.86	1.20	1.37	1.54	1.54	0.84	0.83
Axis X-X	y	0.68	0.85	0.88	0.48	0.60	0.75	1.11	1.29	1.48	1.54	0.71	0.76
Axis Y-Y	I	0.75	0.75	0.90	2.10	1.77	1.77	2.12	2.13	2.13	2.83	2.52	4.13
Axis Y-Y	S	0.50	0.50	0.60	1.05	0.88	0.89	1.06	1.06	1.06	1.42	1.12	1.65
Axis Y-Y	r	0.65	0.62	0.63	0.96	0.90	0.87	0.82	0.79	0.77	0.79	1.00	1.10
	Tools	853-H		853-D	853-L		853-R	853-E		853-S	853-T	853-O	853-Q

*See note on page 86.

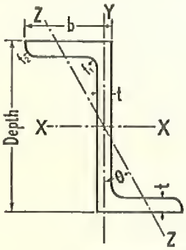


SPECIAL TEES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.
J=Torsion Factor in in.^{4}

Size	Flange	6					8
	Stem	3	4	4	7.50	7.50	6
	t_s t_f	0.312 0.312	0.375 0.313	0.375 0.450	0.50 0.75	1.125 0.75	0.500 0.860
Weight Area		3.33 2.75	4.00 3.30	4.93 4.07	9.73 8.04	14.84 12.26	11.56 9.56
f		0.312	0.313	0.312	⅝	⅝	0.500
Axis X-X	I S r y	1.83 0.77 0.81 0.62	4.78 1.59 1.20 1.00	5.02 1.61 1.11 0.88	40.34 7.28 2.24 1.96	69.34 14.46 2.38 2.71	22.93 4.82 1.55 1.24
Axis Y-Y	I S r	5.63 1.88 1.43	5.65 1.88 1.31	8.12 2.71 1.41	13.60 4.53 1.30	14.38 4.80 1.08	36.76 9.19 1.96
J		0.091	0.132	0.253	1.16	4.40	1.95
Tools		37526	37524	37525	28084	28232	37523



ZEES

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

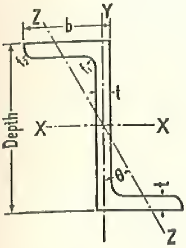
Size										
Size	Nominal depth	1¾	2	2⅜	3					
	t	3/16	3/16	3/16	1/4*	5/16	3/8*	7/16	1/2	9/16
Weight		1.116	0.946	1.031	2.40	3.02	3.48	4.09	4.48	5.08
Area		0.922	0.782	0.852	1.98	2.50	2.87	3.38	3.70	4.20
Actual depth		1¾	2	2⅜	3	3 1/16	3	3 1/16	3	3 1/16
b		1¾	1¼	1¼	2 11/16	2¾	2 11/16	2¾	2 11/16	2¾
f_1		3/16	3/16	3/16	5/16	5/16	5/16	5/16	5/16	5/16
f_2		1/8	1/8	1/8	1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	0.446	0.458	0.694	2.89	3.65	3.86	4.57	4.60	5.26
	S	0.510	0.458	0.584	1.92	2.39	2.57	2.99	3.06	3.44
	r	0.695	0.765	0.902	1.21	1.21	1.16	1.16	1.11	1.12
Axis Y-Y	I	0.551	0.186	0.186	2.64	3.47	3.76	4.59	4.71	5.53
	S	0.333	0.161	0.161	1.03	1.34	1.50	1.81	1.93	2.24
	r	0.773	0.488	0.467	1.15	1.18	1.14	1.17	1.13	1.15
Axis Z-Z	Θ	48° 49′	29° 12′	23° 12′	43° 24′	44° 05′	44° 31′	45° 04′	45° 27′	45° 55′
	I	0.101	0.063	0.082	0.59	0.76	0.82	0.99	1.03	1.22
	r	0.331	0.283	0.310	0.54	0.55	0.53	0.54	0.53	0.54
J		0.012	0.010	0.011	0.044	0.087	0.15	0.24	0.35	0.51
Tools		771-D	771-C	7088	771-B		771-A			

Size							
Size	Nominal depth	4					
	t	1/4*[1]	5/16*	3/8*[2]	7/16	1/2	9/16
Weight		2.93	3.68	4.44	4.92	5.65	6.40
Area		2.42	3.04	3.67	4.06	4.67	5.29
Actual depth		4	4 1/16	4⅛	4	4 1/16	4⅛
b		3 1/16	3⅛	3 3/16	3 1/16	3⅛	3 3/16
f_1		5/16	5/16	5/16	5/16	5/16	5/16
f_2		1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	6.32	7.97	9.66	9.68	11.20	12.76
	S	3.16	3.92	4.68	4.84	5.51	6.19
	r	1.62	1.62	1.62	1.54	1.55	1.55
Axis Y-Y	I	4.01	5.24	6.54	6.53	7.75	9.05
	S	1.36	1.76	2.18	2.30	2.70	3.11
	r	1.29	1.31	1.33	1.27	1.29	1.31
Axis Z-Z	Θ	36° 47′	37° 24′	37° 55′	37° 50′	38° 16′	38° 41′
	I	1.08	1.39	1.72	1.74	2.06	2.41
	r	0.67	0.68	0.68	0.66	0.66	0.68
J		0.053	0.10	0.18	0.28	0.43	0.62
Tools		Rolls	Rolls	Rolls	771-G		771-F

*See note on page 86.

[1]Nominal rolled size in this web thickness is: depth 4 1/32″, flange width 3 3/32″.

[2]Nominal rolled size in this web thickness is: depth 4 5/32″, flange width 3 7/32″.



ZEES

ELEMENTS OF SECTIONS

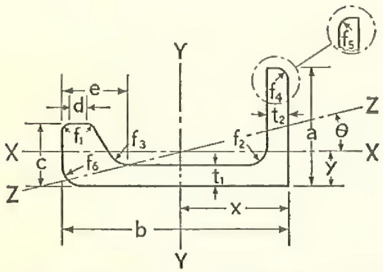
All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.
J=Torsion Factor in in.^{4}

Size		5					
Nominal depth	t	5/16	3/8*	7/16	1/2*	9/16	5/8
Weight		4.13	4.98	5.84	6.37	7.21	8.05
Area		3.41	4.12	4.83	5.27	5.96	6.66
Actual depth		5	5 1/16	5 1/8	5	5 1/16	5 1/8
b		3 1/4	3 5/16	3 3/8	3 1/4	3 5/16	3 3/8
f_1		5/16	5/16	5/16	5/16	5/16	5/16
f_2		1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	13.41	16.23	19.12	19.23	21.87	24.56
	S	5.36	6.41	7.46	7.69	8.64	9.59
	r	1.98	1.99	1.99	1.91	1.92	1.92
Axis Y-Y	I	5.94	7.40	8.95	8.82	10.28	11.82
	S	1.92	2.37	2.84	2.94	3.39	3.86
	r	1.32	1.34	1.36	1.29	1.31	1.33
Axis Z-Z	Θ	30° 40′	31° 08′	31° 32′	31° 09′	31° 32′	31° 53′
	I	1.89	2.33	2.81	2.82	3.29	3.79
	r	0.74	0.75	0.76	0.73	0.74	0.75
J		0.12	0.21	0.33	0.48	0.69	0.97
Tools		771-K	771-E		771-H		

Size		6					
Nominal depth	t	3/8	7/16	1/2	9/16	5/8	11/16
Weight		5.58	6.54	7.51	8.10	9.05	10.00
Area		4.61	5.40	6.20	6.69	7.48	8.27
Actual depth		6	6 1/16	6 1/8	6	6 1/16	6 1/8
b		3 1/2	3 9/16	3 5/8	3 1/2	3 9/16	3 5/8
f_1		5/16	5/16	5/16	5/16	5/16	5/16
f_2		1/4	1/4	1/4	1/4	1/4	1/4
Axis X-X	I	25.40	29.88	34.44	34.71	38.93	43.24
	S	8.47	9.86	11.24	11.57	12.84	14.12
	r	2.35	2.35	2.36	2.28	2.28	2.29
Axis Y-Y	I	8.83	10.66	12.58	12.32	14.15	16.07
	S	2.67	3.19	3.73	3.83	4.35	4.90
	r	1.38	1.40	1.42	1.36	1.38	1.39
Axis Z-Z	Θ	26° 55′	27° 17′	27° 37′	27° 08′	27° 26′	27° 44′
	I	3.08	3.70	4.36	4.36	5.01	5.70
	r	0.82	0.83	0.84	0.81	0.82	0.83
J		0.23	0.37	0.56	0.77	1.07	1.45
Tools							771-L

*See note on page 86.

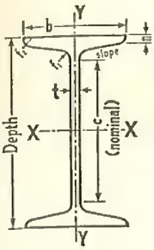
BULB ANGLE



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I=Moment of Inertia in in.[4]
S=Section Modulus in in.[3]
r=Radius of Gyration in inches.

		4 x 3½	5 x 2½	5 x 3½	6 x 3½
Size	Legs	4 x 3½	5 x 2½	5 x 3½	6 x 3½
	t_1	⅜	¼	⅜	0.28
	t_2	⅜	¼	⅜	0.31
	Weight	4.32	2.58	4.77	3.80
	Area	3.57	2.13	3.94	3.14
	a	3.50	2.50	3.50	3.51
	b	4.00	5.00	5.00	6.01
	c	1.50	0.875	1.50	1.06
	d	5/16	0	5/16	0
	e	1¼	0.79	1¼	0.97
	f_1	⅛	0	⅛	0
	f_2	⅜	0.20	⅜	0.24
	f_3	¼	0.20	¼	0.24
	f_4	3/16	0	3/16	0
	f_5	0	0.21	0	0.27
	f_6	⅜	0.42	⅜	0.54
Axis X-X	I	3.02	0.82	3.21	2.70
	S	1.18	0.41	1.22	0.98
	r	0.92	0.62	0.90	0.93
	y	0.93	0.50	0.86	0.74
Axis Y-Y	I	7.95	7.10	13.82	15.44
	S	3.58	2.49	5.05	4.33
	r	1.49	1.82	1.87	2.22
	x	1.78	2.15	2.26	2.44
Axis Z-Z	Θ	20° 13′	9° 35′	13° 53′	13° 21′
	I	2.24	0.64	2.52	1.94
	r	0.79	0.55	0.80	0.79
	Tools	5022	32166	37221	38669

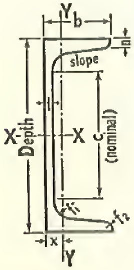


SPECIAL I-BEAMS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.
J = Torsion Factor in in.^{4}

Size	Depth	2		2½
Size	t	0.094	0.188	0.250
	Weight	0.804	1.473	1.850
	Area	0.664	1.217	1.529
	b	2.00	2.00	2.00
	Slope	0	1:11.4	1:7
	n	0.125	0.188	0.188
	f_1	0.125	0.188	0.250
	f_2	0.125	0.094	0.125
	c	1½	1⅛	1⅜
Axis X-X	I	0.481	0.782	1.453
Axis X-X	S	0.481	0.782	1.162
Axis X-X	r	0.85	0.80	0.97
Axis Y-Y	I	0.154	0.275	0.292
Axis Y-Y	S	0.154	0.275	0.292
Axis Y-Y	r	0.48	0.47	0.44
	J	0.004	0.025	0.091
	Tools	8606	10096	4465



SPECIAL CHANNELS

ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.
I = Moment of Inertia in in.[4]

S = Section Modulus in in.[3]
r = Radius of Gyration in inches.
J = Torsion Factor in in.[4]

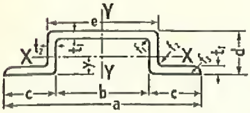
Size: Depth	2	2½	3	3	4	5	5	5
Size: t	0.170	0.250	0.250*	0.375*	0.318*	0.188	0.500	0.438*
Weight	1.253	1.277	2.30	2.78	3.41	3.19	4.88	5.99
Area	1.036	1.055	1.90	2.30	2.82	2.64	4.03	4.95
b	1.41	1.250	2.000	2.000	2.500	2.875	2.500	2.875
Slope	1:6.0	1:6.0	1:12.1	0	1:34.9	1:10.7	0	1:9.8
n	0.170	0.125	0.250	0.375	0.313	0.188	0.375	0.438
f_1	0.270	0.250	0.250	0.188	0.375	0.250	0.375	0.250
f_2	0.100	0.125	0	0.375	0.125	0.094	0.250	0.094
c	¾	1⅜	1¾	1¾	2⅜	3½	3½	3
Axis X-X: I	0.621	0.879	2.61	2.89	6.84	11.20	13.37	18.13
Axis X-X: S	0.621	0.703	1.74	1.92	3.42	4.48	5.35	7.25
Axis X-X: r	0.775	0.913	1.17	1.12	1.56	2.06	1.82	1.91
Axis Y-Y: I	0.172	0.111	0.68	0.78	1.62	1.91	1.94	3.57
Axis Y-Y: S	0.188	0.122	0.52	0.59	0.95	0.96	1.08	1.87
Axis Y-Y: r	0.407	0.324	0.60	0.58	0.76	0.85	0.69	0.85
Axis Y-Y: x	0.494	0.344	0.68	0.67	0.81	0.89	0.71	0.96
J	0.029	0.025	0.068	0.12	0.50	0.18	0.30	0.55
Tools	852-H	7400	5287	2229	4885	1351	1665	1052

Size: Depth	6	6	8	8	10	10	10
Size: t	0.500*	0.375*	0.380*	0.425*	0.375*	0.438*	0.500*
Weight	5.94	6.10	6.78	8.09	8.84	9.59	10.34
Area	4.91	5.04	5.60	6.68	7.30	7.93	8.55
b	3.000	3.500	3.000	3.500	3.500	3.563	3.625
Slope	0	1:49.6	1:14.43	1:28.5	1:9	1:9	1:9
n	0.375	0.412	0.380	0.471	0.375	0.375	0.375
f_1	0.375	0.480	0.550	0.525	0.625	0.625	0.625
f_2	0.250	0.420	0.220	0.375	0.188	0.188	0.188
c	4½	4	5¾	5¾	7½	7½	7½
Axis X-X: I	24.05	28.22	54.15	63.76	109.62	114.87	120.03
Axis X-X: S	8.02	9.41	13.54	15.94	21.92	22.97	24.01
Axis X-X: r	2.21	2.37	3.11	3.09	3.88	3.81	3.75
Axis Y-Y: I	3.52	5.58	4.10	7.06	7.19	7.73	8.25
Axis Y-Y: S	1.61	2.31	1.88	2.84	2.80	2.93	3.04
Axis Y-Y: r	0.85	1.05	0.86	1.03	0.99	0.99	0.98
Axis Y-Y: x	0.81	1.09	0.81	1.01	0.93	0.92	0.91
J	0.36	0.32	0.383	0.56	0.66	0.78	0.94
Tools	1666	2658	11866	10005	Rolls	Rolls	Rolls

*See note on page 86.

WING CHANNELS

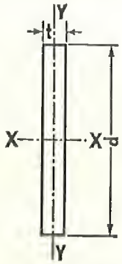
ELEMENTS OF SECTIONS



All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in $in.^4$
S = Section Modulus in $in.^3$
r = Radius of Gyration in inches.

Width, a		3½	4			4¾	5		7½	8¾
Weight		0.537	0.794	0.925	1.173	1.30	1.15	1.90	4.97	5.02
Area		0.444	0.656	0.765	0.969	1.08	0.95	1.57	4.11	4.15
b		2 1/16	1¾	1¾	1 5/16	2	2¾	1⅝	2⅛	4⅛
c		23/32	1⅛	1⅛	1 11/32	1⅜	1⅛	1 11/16	2 11/16	2 5/16
Depth, d		¾	¾	1⅛	2	2	1½	1⅞	3⅜	3⅛
e		2¼	2	2	1½	2¼	3	2	2¾	4⅝
Thickness, t_1		3/32	⅛	⅛	5/32	⅛	⅛	3/16	5/16	5/16
Thickness, t_2		3/32	⅛	⅛	3/32	⅛	⅛	3/16	5/16	¼
f_1		3/32	⅛	⅛	⅛	⅛	⅛	⅛	⅛	⅛
f_2		3/32	⅛	3/16	0	⅛	3/16	¼	⅛	⅛
f_3		0	⅛	1/32	⅛	0	0	⅛	0	⅛
Axis X-X	I	0.038	0.054	0.148	0.603	0.668	0.339	0.778	6.28	6.40
	S	0.116	0.139	0.251	0.517	0.634	0.485	0.709	3.15	4.10
	r	0.293	0.288	0.440	0.789	0.788	0.597	0.704	1.24	1.24
	y	0.420	0.359	0.533	0.833	0.946	0.803	0.778	1.38	1.56
Axis Y-Y	I	0.484	0.804	0.946	0.980	1.69	1.97	2.53	13.66	24.23
	S	0.276	0.402	0.473	0.490	0.71	0.79	1.01	3.64	5.54
	r	1.044	1.107	1.112	1.006	1.25	1.44	1.27	1.82	2.42
Tools		9004	7838	4277	8604	9498	4619	5899	5023	



RECTANGLES

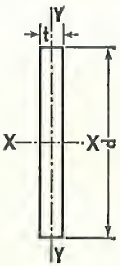
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
1	Wt.	0.151	0.227	0.303	0.378	0.454	0.529	0.605	0.681	0.756	0.908	1.059	1.210
	Area	0.125	0.188	0.250	0.313	0.375	0.438	0.500	0.563	0.625	0.750	0.875	1.000
	I x-x	0.010	0.016	0.021	0.026	0.031	0.037	0.042	0.047	0.052	0.063	0.073	0.083
	I y-y	0.000	0.001	0.001	0.003	0.004	0.007	0.010	0.015	0.020	0.035	0.056	0.083
1 1/8	Wt.	0.170	0.255	0.340	0.425	0.510	0.596	0.681	0.766	0.851	1.021	1.191	1.361
	Area	0.141	0.211	0.281	0.352	0.422	0.492	0.563	0.633	0.703	0.844	0.984	1.125
	I x-x	0.015	0.022	0.030	0.037	0.045	0.052	0.059	0.067	0.074	0.089	0.104	0.119
	I y-y	0.000	0.001	0.001	0.003	0.005	0.008	0.012	0.017	0.023	0.040	0.063	0.094
1 1/4	Wt.	0.189	0.284	0.378	0.473	0.567	0.662	0.756	0.851	0.945	1.134	1.324	1.513
	Area	0.156	0.234	0.313	0.391	0.469	0.547	0.625	0.703	0.781	0.938	1.094	1.250
	I x-x	0.020	0.031	0.041	0.051	0.061	0.071	0.081	0.092	0.102	0.122	0.142	0.163
	I y-y	0.000	0.001	0.002	0.003	0.005	0.009	0.013	0.019	0.025	0.044	0.070	0.104
1 3/8	Wt.	0.208	0.312	0.416	0.520	0.624	0.728	0.832	0.936	1.040	1.248	1.456	1.664
	Area	0.172	0.258	0.344	0.430	0.516	0.602	0.688	0.773	0.859	1.031	1.203	1.375
	I x-x	0.027	0.041	0.054	0.068	0.081	0.095	0.108	0.122	0.135	0.163	0.190	0.217
	I y-y	0.000	0.001	0.002	0.003	0.006	0.010	0.014	0.020	0.028	0.048	0.077	0.115
1 1/2	Wt.	0.227	0.340	0.454	0.567	0.681	0.794	0.908	1.021	1.134	1.361	1.588	1.815
	Area	0.188	0.281	0.375	0.469	0.563	0.656	0.750	0.844	0.938	1.125	1.313	1.500
	I x-x	0.035	0.053	0.070	0.088	0.106	0.123	0.141	0.158	0.176	0.211	0.246	0.281
	I y-y	0.000	0.001	0.002	0.004	0.007	0.010	0.016	0.022	0.031	0.053	0.084	0.125
1 5/8	Wt.	0.246	0.369	0.492	0.614	0.737	0.860	0.983	1.106	1.229	1.475	1.720	1.966
	Area	0.203	0.305	0.406	0.508	0.609	0.711	0.813	0.914	1.016	1.219	1.422	1.625
	I x-x	0.045	0.067	0.089	0.112	0.134	0.156	0.179	0.201	0.224	0.268	0.313	0.358
	I y-y	0.000	0.001	0.002	0.004	0.007	0.011	0.017	0.024	0.033	0.057	0.091	0.135
1 3/4	Wt.	0.265	0.397	0.529	0.662	0.794	0.926	1.059	1.191	1.323	1.588	1.853	2.118
	Area	0.219	0.328	0.438	0.547	0.656	0.766	0.875	0.984	1.094	1.313	1.531	1.750
	I x-x	0.056	0.084	0.112	0.140	0.168	0.195	0.223	0.251	0.279	0.335	0.391	0.447
	I y-y	0.000	0.001	0.002	0.004	0.008	0.012	0.018	0.026	0.036	0.062	0.098	0.146
1 7/8	Wt.	0.284	0.425	0.567	0.709	0.851	0.993	1.134	1.276	1.418	1.702	1.985	2.269
	Area	0.234	0.352	0.469	0.586	0.703	0.820	0.938	1.055	1.172	1.406	1.641	1.875
	I x-x	0.069	0.103	0.137	0.172	0.206	0.240	0.275	0.309	0.343	0.412	0.481	0.549
	I y-y	0.000	0.001	0.002	0.005	0.008	0.013	0.020	0.028	0.038	0.066	0.105	0.156



RECTANGLES

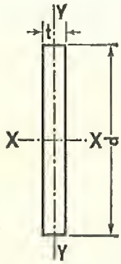
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
2	Wt.	0.303	0.454	0.605	0.756	0.908	1.059	1.210	1.361	1.513	1.815	2.118	2.420
	Area	0.250	0.375	0.500	0.625	0.750	0.875	1.000	1.125	1.250	1.500	1.750	2.000
	I x-x	0.083	0.125	0.167	0.208	0.250	0.292	0.333	0.375	0.417	0.500	0.583	0.667
	I y-y	0.000	0.001	0.003	0.005	0.009	0.014	0.021	0.030	0.041	0.070	0.112	0.167
2 1/8	Wt.	0.321	0.482	0.643	0.804	0.964	1.125	1.286	1.446	1.607	1.928	2.250	2.571
	Area	0.266	0.398	0.531	0.664	0.797	0.930	1.063	1.195	1.328	1.594	1.859	2.125
	I x-x	0.100	0.150	0.200	0.250	0.300	0.350	0.400	0.450	0.500	0.600	0.700	0.800
	I y-y	0.000	0.001	0.003	0.005	0.009	0.015	0.022	0.032	0.043	0.075	0.119	0.177
2 1/4	Wt.	0.340	0.510	0.681	0.851	1.021	1.191	1.361	1.531	1.702	2.042	2.382	2.723
	Area	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406	1.688	1.969	2.250
	I x-x	0.119	0.178	0.237	0.297	0.356	0.415	0.475	0.534	0.593	0.712	0.831	0.949
	I y-y	0.000	0.001	0.003	0.006	0.010	0.016	0.023	0.033	0.046	0.079	0.126	0.187
2 3/8	Wt.	0.359	0.539	0.718	0.898	1.078	1.257	1.437	1.616	1.796	2.155	2.515	2.874
	Area	0.297	0.445	0.594	0.742	0.891	1.039	1.188	1.336	1.484	1.781	2.078	2.375
	I x-x	0.140	0.209	0.279	0.349	0.419	0.488	0.558	0.628	0.698	0.837	0.977	1.116
	I y-y	0.000	0.001	0.003	0.006	0.010	0.017	0.025	0.035	0.048	0.083	0.133	0.198
2 1/2	Wt.	0.378	0.567	0.756	0.945	1.134	1.323	1.513	1.702	1.891	2.269	2.647	3.025
	Area	0.313	0.469	0.625	0.781	0.938	1.094	1.250	1.406	1.563	1.875	2.188	2.500
	I x-x	0.163	0.244	0.326	0.407	0.488	0.570	0.651	0.732	0.814	0.977	1.139	1.302
	I y-y	0.000	0.001	0.003	0.006	0.011	0.017	0.026	0.037	0.051	0.088	0.140	0.208
2 5/8	Wt.	0.397	0.596	0.794	0.993	1.191	1.390	1.588	1.787	1.985	2.382	2.779	3.176
	Area	0.328	0.492	0.656	0.820	0.984	1.148	1.313	1.477	1.641	1.969	2.297	2.625
	I x-x	0.188	0.283	0.377	0.471	0.565	0.660	0.754	0.848	0.942	1.131	1.319	1.507
	I y-y	0.000	0.001	0.003	0.007	0.012	0.018	0.027	0.039	0.053	0.092	0.147	0.219
2 3/4	Wt.	0.416	0.624	0.832	1.040	1.248	1.456	1.664	1.872	2.080	2.496	2.912	3.328
	Area	0.344	0.516	0.688	0.859	1.031	1.203	1.375	1.547	1.719	2.063	2.406	2.750
	I x-x	0.217	0.325	0.433	0.542	0.650	0.758	0.867	0.975	1.083	1.300	1.517	1.733
	I y-y	0.000	0.002	0.004	0.007	0.012	0.019	0.029	0.041	0.056	0.097	0.154	0.229
2 7/8	Wt.	0.435	0.652	0.870	1.087	1.305	1.522	1.739	1.957	2.174	2.609	3.044	3.479
	Area	0.359	0.539	0.719	0.898	1.078	1.258	1.438	1.617	1.797	2.156	2.516	2.875
	I x-x	0.248	0.371	0.495	0.619	0.743	0.866	0.990	1.114	1.238	1.485	1.733	1.980
	I y-y	0.000	0.002	0.004	0.007	0.013	0.020	0.030	0.043	0.058	0.101	0.161	0.240



RECTANGLES

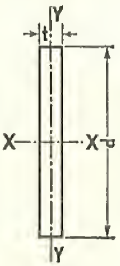
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in $in.^4$

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
3	Wt.	0.454	0.681	0.908	1.134	1.361	1.588	1.815	2.042	2.269	2.723	3.176	3.630
	Area	0.375	0.563	0.750	0.938	1.125	1.313	1.500	1.688	1.875	2.250	2.625	3.000
	I x-x	0.281	0.422	0.563	0.703	0.844	0.984	1.125	1.266	1.406	1.688	1.969	2.250
	I y-y	0.000	0.002	0.004	0.008	0.013	0.021	0.031	0.044	0.061	0.105	0.167	0.250
3 1/8	Wt.	0.473	0.709	0.945	1.182	1.418	1.654	1.891	2.127	2.363	2.836	3.309	3.781
	Area	0.391	0.586	0.781	0.977	1.172	1.367	1.563	1.758	1.953	2.344	2.734	3.125
	I x-x	0.318	0.477	0.636	0.795	0.954	1.113	1.272	1.431	1.590	1.907	2.225	2.543
	I y-y	0.001	0.002	0.004	0.008	0.014	0.022	0.033	0.046	0.064	0.110	0.174	0.260
3 1/4	Wt.	0.492	0.737	0.983	1.229	1.475	1.720	1.966	2.212	2.458	2.949	3.441	3.933
	Area	0.406	0.609	0.813	1.016	1.219	1.422	1.625	1.828	2.031	2.438	2.844	3.250
	I x-x	0.358	0.536	0.715	0.894	1.073	1.252	1.430	1.609	1.788	2.146	2.503	2.861
	I y-y	0.001	0.002	0.004	0.008	0.014	0.023	0.034	0.048	0.066	0.114	0.181	0.271
3 3/8	Wt.	0.510	0.766	1.021	1.276	1.531	1.787	2.042	2.297	2.552	3.063	3.573	4.084
	Area	0.422	0.633	0.844	1.055	1.266	1.477	1.688	1.898	2.109	2.531	2.953	3.375
	I x-x	0.401	0.601	0.801	1.001	1.201	1.402	1.602	1.802	2.002	2.403	2.803	3.204
	I y-y	0.001	0.002	0.004	0.009	0.015	0.024	0.035	0.050	0.069	0.119	0.188	0.281
3 1/2	Wt.	0.529	0.794	1.059	1.323	1.588	1.853	2.118	2.382	2.647	3.176	3.706	4.235
	Area	0.438	0.656	0.875	1.094	1.313	1.531	1.750	1.969	2.188	2.625	3.063	3.500
	I x-x	0.447	0.670	0.893	1.117	1.340	1.563	1.787	2.010	2.233	2.680	3.126	3.573
	I y-y	0.001	0.002	0.005	0.009	0.015	0.024	0.036	0.052	0.071	0.123	0.195	0.292
3 5/8	Wt.	0.548	0.822	1.097	1.371	1.645	1.919	2.193	2.467	2.741	3.290	3.838	4.386
	Area	0.453	0.680	0.906	1.133	1.359	1.586	1.813	2.039	2.266	2.719	3.172	3.625
	I x-x	0.496	0.744	0.992	1.241	1.489	1.737	1.985	2.233	2.481	2.977	3.473	3.970
	I y-y	0.001	0.002	0.005	0.009	0.016	0.025	0.038	0.054	0.074	0.127	0.202	0.302
3 3/4	Wt.	0.567	0.851	1.134	1.418	1.702	1.985	2.269	2.552	2.836	3.403	3.971	4.538
	Area	0.469	0.703	0.938	1.172	1.406	1.641	1.875	2.109	2.344	2.813	3.281	3.750
	I x-x	0.549	0.824	1.099	1.373	1.648	1.923	2.197	2.472	2.747	3.296	3.845	4.395
	I y-y	0.001	0.002	0.005	0.010	0.016	0.026	0.039	0.056	0.076	0.132	0.209	0.312
3 7/8	Wt.	0.586	0.879	1.172	1.465	1.758	2.051	2.344	2.637	2.930	3.517	4.103	4.689
	Area	0.484	0.727	0.969	1.211	1.453	1.695	1.938	2.180	2.422	2.906	3.391	3.875
	I x-x	0.606	0.909	1.212	1.515	1.818	2.121	2.424	2.728	3.031	3.637	4.243	4.849
	I y-y	0.001	0.002	0.005	0.010	0.017	0.027	0.040	0.057	0.079	0.136	0.216	0.323



RECTANGLES

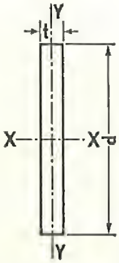
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
4	Wt.	0.605	0.908	1.210	1.513	1.815	2.118	2.420	2.723	3.025	3.630	4.235	4.840
	Area	0.500	0.750	1.000	1.250	1.500	1.750	2.000	2.250	2.500	3.000	3.500	4.000
	I x-x	0.667	1.000	1.333	1.667	2.000	2.333	2.667	3.000	3.333	4.000	4.667	5.333
	I y-y	0.001	0.002	0.005	0.010	0.018	0.028	0.042	0.059	0.081	0.141	0.223	0.333
4 1/8	Wt.	0.624	0.936	1.248	1.560	1.872	2.184	2.496	2.808	3.120	3.743	4.367	4.991
	Area	0.516	0.773	1.031	1.289	1.547	1.805	2.063	2.320	2.578	3.094	3.609	4.125
	I x-x	0.731	1.097	1.462	1.828	2.193	2.559	2.925	3.290	3.656	4.387	5.118	5.849
	I y-y	0.001	0.002	0.005	0.010	0.018	0.029	0.043	0.061	0.084	0.145	0.230	0.344
4 1/4	Wt.	0.643	0.964	1.286	1.607	1.928	2.250	2.571	2.893	3.214	3.857	4.500	5.143
	Area	0.531	0.797	1.063	1.328	1.594	1.859	2.125	2.391	2.656	3.188	3.719	4.250
	I x-x	0.800	1.200	1.599	1.999	2.399	2.799	3.199	3.598	3.998	4.798	5.598	6.397
	I y-y	0.001	0.002	0.006	0.011	0.019	0.030	0.044	0.063	0.086	0.149	0.237	0.354
4 3/8	Wt.	0.662	0.993	1.323	1.654	1.985	2.316	2.647	2.978	3.309	3.970	4.632	5.294
	Area	0.547	0.820	1.094	1.367	1.641	1.914	2.188	2.461	2.734	3.281	3.828	4.375
	I x-x	0.872	1.308	1.745	2.181	2.617	3.053	3.489	3.925	4.362	5.234	6.106	6.978
	I y-y	0.001	0.002	0.006	0.011	0.019	0.031	0.046	0.065	0.089	0.154	0.244	0.365
4 1/2	Wt.	0.681	1.021	1.361	1.702	2.042	2.382	2.723	3.063	3.403	4.084	4.764	5.445
	Area	0.563	0.844	1.125	1.406	1.688	1.969	2.250	2.531	2.813	3.375	3.938	4.500
	I x-x	0.949	1.424	1.898	2.373	2.848	3.322	3.797	4.272	4.746	5.695	6.645	7.594
	I y-y	0.001	0.002	0.006	0.011	0.020	0.031	0.047	0.067	0.092	0.158	0.251	0.375
4 5/8	Wt.	0.700	1.049	1.399	1.749	2.099	2.448	2.798	3.148	3.498	4.197	4.897	5.596
	Area	0.578	0.867	1.156	1.445	1.734	2.023	2.313	2.602	2.891	3.469	4.047	4.625
	I x-x	1.031	1.546	2.061	2.576	3.092	3.607	4.122	4.637	5.153	6.183	7.214	8.244
	I y-y	0.001	0.003	0.006	0.012	0.020	0.032	0.048	0.069	0.094	0.163	0.258	0.385
4 3/4	Wt.	0.718	1.078	1.437	1.796	2.155	2.515	2.874	3.233	3.592	4.311	5.029	5.748
	Area	0.594	0.891	1.188	1.484	1.781	2.078	2.375	2.672	2.969	3.563	4.156	4.750
	I x-x	1.116	1.675	2.233	2.791	3.349	3.907	4.466	5.024	5.582	6.698	7.815	8.931
	I y-y	0.001	0.003	0.006	0.012	0.021	0.033	0.049	0.070	0.097	0.167	0.265	0.396
4 7/8	Wt.	0.737	1.106	1.475	1.843	2.212	2.581	2.949	3.318	3.687	4.424	5.162	5.899
	Area	0.609	0.914	1.219	1.523	1.828	2.133	2.438	2.742	3.047	3.656	4.266	4.875
	I x-x	1.207	1.810	2.414	3.017	3.621	4.224	4.827	5.431	6.034	7.241	8.448	9.655
	I y-y	0.001	0.003	0.006	0.012	0.021	0.034	0.051	0.072	0.099	0.171	0.272	0.406



RECTANGLES

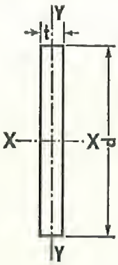
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in $in.^4$

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
5	Wt.	0.756	1.134	1.513	1.891	2.269	2.647	3.025	3.403	3.781	4.538	5.294	6.050
	Area	0.625	0.938	1.250	1.563	1.875	2.188	2.500	2.813	3.125	3.750	4.375	5.000
	I x-x	1.302	1.953	2.604	3.255	3.906	4.557	5.208	5.859	6.510	7.813	9.115	10.42
	I y-y	0.001	0.003	0.007	0.013	0.022	0.035	0.052	0.074	0.102	0.176	0.279	0.417
5 1/8	Wt.	0.775	1.163	1.550	1.938	2.325	2.713	3.101	3.488	3.876	4.651	5.426	6.201
	Area	0.641	0.961	1.281	1.602	1.922	2.242	2.563	2.883	3.203	3.844	4.484	5.125
	I x-x	1.402	2.103	2.804	3.506	4.207	4.908	5.609	6.310	7.011	8.413	9.815	11.22
	I y-y	0.001	0.003	0.007	0.013	0.023	0.036	0.053	0.076	0.104	0.180	0.286	0.427
5 1/4	Wt.	0.794	1.191	1.588	1.985	2.382	2.779	3.176	3.573	3.970	4.764	5.558	6.353
	Area	0.656	0.984	1.313	1.641	1.969	2.297	2.625	2.953	3.281	3.938	4.594	5.250
	I x-x	1.507	2.261	3.015	3.768	4.522	5.276	6.029	6.783	7.537	9.044	10.55	12.06
	I y-y	0.001	0.003	0.007	0.013	0.023	0.037	0.055	0.078	0.107	0.185	0.293	0.437
5 3/8	Wt.	0.813	1.219	1.626	2.032	2.439	2.845	3.252	3.658	4.065	4.878	5.691	6.504
	Area	0.672	1.008	1.344	1.680	2.016	2.352	2.688	3.023	3.359	4.031	4.703	5.375
	I x-x	1.618	2.426	3.235	4.044	4.853	5.662	6.470	7.279	8.088	9.705	11.32	12.94
	I y-y	0.001	0.003	0.007	0.014	0.024	0.038	0.056	0.080	0.109	0.189	0.300	0.448
5 1/2	Wt.	0.832	1.248	1.664	2.080	2.496	2.912	3.328	3.743	4.159	4.991	5.823	6.655
	Area	0.688	1.031	1.375	1.719	2.063	2.406	2.750	3.094	3.438	4.125	4.813	5.500
	I x-x	1.733	2.600	3.466	4.333	5.199	6.066	6.932	7.799	8.665	10.40	12.13	13.86
	I y-y	0.001	0.003	0.007	0.014	0.024	0.038	0.057	0.082	0.112	0.193	0.307	0.458
5 5/8	Wt.	0.851	1.276	1.702	2.127	2.552	2.978	3.403	3.829	4.254	5.105	5.955	6.806
	Area	0.703	1.055	1.406	1.758	2.109	2.461	2.813	3.164	3.516	4.219	4.922	5.625
	I x-x	1.854	2.781	3.708	4.635	5.562	6.489	7.416	8.343	9.270	11.12	12.98	14.83
	I y-y	0.001	0.003	0.007	0.014	0.025	0.039	0.059	0.083	0.114	0.198	0.314	0.469
5 3/4	Wt.	0.870	1.305	1.739	2.174	2.609	3.044	3.479	3.914	4.348	5.218	6.088	6.958
	Area	0.719	1.078	1.438	1.797	2.156	2.516	2.875	3.234	3.594	4.313	5.031	5.750
	I x-x	1.980	2.971	3.961	4.951	5.941	6.931	7.921	8.911	9.902	11.88	13.86	15.84
	I y-y	0.001	0.003	0.007	0.015	0.025	0.040	0.060	0.085	0.117	0.202	0.321	0.479
5 7/8	Wt.	0.889	1.333	1.777	2.222	2.666	3.110	3.554	3.999	4.443	5.332	6.220	7.109
	Area	0.734	1.102	1.469	1.836	2.203	2.570	2.938	3.305	3.672	4.406	5.141	5.875
	I x-x	2.112	3.168	4.225	5.281	6.337	7.393	8.449	9.505	10.56	12.67	14.79	16.90
	I y-y	0.001	0.003	0.008	0.015	0.026	0.041	0.061	0.087	0.120	0.207	0.328	0.490



RECTANGLES

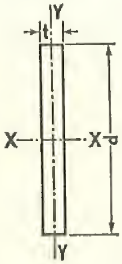
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in $in.^4$

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
6	Wt.	0.908	1.361	1.815	2.269	2.723	3.176	3.630	4.084	4.538	5.445	6.353	7.260
	Area	0.750	1.125	1.500	1.875	2.250	2.625	3.000	3.375	3.750	4.500	5.250	6.000
	I x-x	2.250	3.375	4.500	5.625	6.750	7.875	9.000	10.13	11.25	13.50	15.75	18.00
	I y-y	0.001	0.003	0.008	0.015	0.026	0.042	0.063	0.089	0.122	0.211	0.335	0.500
6 1/8	Wt.	0.926	1.390	1.853	2.316	2.779	3.242	3.706	4.169	4.632	5.558	6.485	7.411
	Area	0.766	1.148	1.531	1.914	2.297	2.680	3.063	3.445	3.828	4.594	5.359	6.125
	I x-x	2.394	3.590	4.787	5.984	7.181	8.378	9.574	10.77	11.97	14.36	16.76	19.15
	I y-y	0.001	0.003	0.008	0.016	0.027	0.043	0.064	0.091	0.125	0.215	0.342	0.510
6 1/4	Wt.	0.945	1.418	1.891	2.363	2.836	3.309	3.781	4.254	4.727	5.672	6.617	7.563
	Area	0.781	1.172	1.563	1.953	2.344	2.734	3.125	3.516	3.906	4.688	5.469	6.250
	I x-x	2.543	3.815	5.086	6.358	7.629	8.901	10.17	11.44	12.72	15.26	17.80	20.35
	I y-y	0.001	0.003	0.008	0.016	0.027	0.044	0.065	0.093	0.127	0.220	0.349	0.521
6 3/8	Wt.	0.964	1.446	1.928	2.411	2.893	3.375	3.857	4.339	4.821	5.785	6.750	7.714
	Area	0.797	1.195	1.594	1.992	2.391	2.789	3.188	3.586	3.984	4.781	5.578	6.375
	I x-x	2.699	4.048	5.398	6.747	8.096	9.446	10.80	12.14	13.49	16.19	18.89	21.59
	I y-y	0.001	0.004	0.008	0.016	0.028	0.044	0.066	0.095	0.130	0.224	0.356	0.531
6 1/2	Wt.	0.983	1.475	1.966	2.458	2.949	3.441	3.933	4.424	4.916	5.899	6.882	7.865
	Area	0.813	1.219	1.625	2.031	2.438	2.844	3.250	3.656	4.063	4.875	5.688	6.500
	I x-x	2.861	4.291	5.721	7.152	8.582	10.01	11.44	12.87	14.30	17.16	20.02	22.89
	I y-y	0.001	0.004	0.008	0.017	0.029	0.045	0.068	0.096	0.132	0.229	0.363	0.542
6 5/8	Wt.	1.002	1.503	2.004	2.505	3.006	3.507	4.008	4.509	5.010	6.012	7.014	8.016
	Area	0.828	1.242	1.656	2.070	2.484	2.898	3.313	3.727	4.141	4.969	5.797	6.625
	I x-x	3.029	4.543	6.058	7.572	9.087	10.60	12.12	13.63	15.14	18.17	21.20	24.23
	I y-y	0.001	0.004	0.009	0.017	0.029	0.046	0.069	0.098	0.135	0.233	0.370	0.552
6 3/4	Wt.	1.021	1.531	2.042	2.552	3.063	3.573	4.084	4.594	5.105	6.126	7.147	8.168
	Area	0.844	1.266	1.688	2.109	2.531	2.953	3.375	3.797	4.219	5.063	5.906	6.750
	I x-x	3.204	4.805	6.407	8.009	9.611	11.21	12.81	14.42	16.02	19.22	22.43	25.63
	I y-y	0.001	0.004	0.009	0.017	0.030	0.047	0.070	0.100	0.137	0.237	0.377	0.562
6 7/8	Wt.	1.040	1.560	2.080	2.600	3.120	3.639	4.159	4.679	5.199	6.239	7.279	8.319
	Area	0.859	1.289	1.719	2.148	2.578	3.008	3.438	3.867	4.297	5.156	6.016	6.875
	I x-x	3.385	5.077	6.770	8.462	10.15	11.85	13.54	15.23	16.92	20.31	23.69	27.08
	I y-y	0.001	0.004	0.009	0.017	0.030	0.048	0.072	0.102	0.140	0.242	0.384	0.573



RECTANGLES

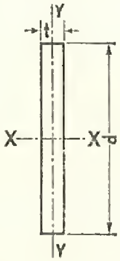
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
7	Wt.	1.059	1.588	2.118	2.647	3.176	3.706	4.235	4.764	5.294	6.353	7.411	8.470
	Area	0.875	1.313	1.750	2.188	2.625	3.063	3.500	3.938	4.375	5.250	6.125	7.000
	I x-x	3.573	5.359	7.146	8.932	10.72	12.51	14.29	16.08	17.86	21.44	25.01	28.58
	I y-y	0.001	0.004	0.009	0.018	0.031	0.049	0.073	0.104	0.142	0.246	0.391	0.583
7 1/8	Wt.	1.078	1.616	2.155	2.694	3.233	3.772	4.311	4.849	5.388	6.466	7.544	8.621
	Area	0.891	1.336	1.781	2.227	2.672	3.117	3.563	4.008	4.453	5.344	6.234	7.125
	I x-x	3.768	5.652	7.536	9.419	11.30	13.19	15.07	16.95	18.84	22.61	26.37	30.14
	I y-y	0.001	0.004	0.009	0.018	0.031	0.050	0.074	0.106	0.145	0.250	0.398	0.594
7 1/4	Wt.	1.097	1.645	2.193	2.741	3.290	3.838	4.386	4.935	5.483	6.579	7.676	8.773
	Area	0.906	1.359	1.813	2.266	2.719	3.172	3.625	4.078	4.531	5.438	6.344	7.250
	I x-x	3.970	5.954	7.939	9.924	11.91	13.89	15.88	17.86	19.85	23.82	27.79	31.76
	I y-y	0.001	0.004	0.009	0.018	0.032	0.051	0.076	0.108	0.148	0.255	0.405	0.604
7 3/8	Wt.	1.115	1.673	2.231	2.789	3.346	3.904	4.462	5.020	5.577	6.693	7.808	8.924
	Area	0.922	1.383	1.844	2.305	2.766	3.227	3.688	4.148	4.609	5.531	6.453	7.375
	I x-x	4.178	6.268	8.357	10.45	12.54	14.62	16.71	18.80	20.89	25.07	29.25	33.43
	I y-y	0.001	0.004	0.010	0.019	0.032	0.051	0.077	0.109	0.150	0.259	0.412	0.615
7 1/2	Wt.	1.134	1.702	2.269	2.836	3.403	3.970	4.538	5.105	5.672	6.806	7.941	9.075
	Area	0.938	1.406	1.875	2.344	2.813	3.281	3.750	4.219	4.688	5.625	6.563	7.500
	I x-x	4.395	6.592	8.789	10.99	13.18	15.38	17.58	19.78	21.97	26.37	30.76	35.16
	I y-y	0.001	0.004	0.010	0.019	0.033	0.052	0.078	0.111	0.153	0.264	0.419	0.625
7 5/8	Wt.	1.153	1.730	2.307	2.883	3.460	4.036	4.613	5.190	5.766	6.920	8.073	9.226
	Area	0.953	1.430	1.906	2.383	2.859	3.336	3.813	4.289	4.766	5.719	6.672	7.625
	I x-x	4.618	6.927	9.236	11.54	13.85	16.16	18.47	20.78	23.09	27.71	32.33	36.94
	I y-y	0.001	0.004	0.010	0.019	0.034	0.053	0.079	0.113	0.155	0.268	0.426	0.635
7 3/4	Wt.	1.172	1.758	2.344	2.930	3.517	4.103	4.689	5.275	5.861	7.033	8.205	9.378
	Area	0.969	1.453	1.938	2.422	2.906	3.391	3.875	4.359	4.844	5.813	6.781	7.750
	I x-x	4.849	7.273	9.698	12.12	14.55	16.97	19.40	21.82	24.24	29.09	33.94	38.79
	I y-y	0.001	0.004	0.010	0.020	0.034	0.054	0.081	0.115	0.158	0.272	0.433	0.646
7 7/8	Wt.	1.191	1.787	2.382	2.978	3.573	4.169	4.764	5.360	5.955	7.147	8.338	9.529
	Area	0.984	1.477	1.969	2.461	2.953	3.445	3.938	4.430	4.922	5.906	6.891	7.875
	I x-x	5.087	7.631	10.17	12.72	15.26	17.81	20.35	22.89	25.44	30.52	35.61	40.70
	I y-y	0.001	0.004	0.010	0.020	0.035	0.055	0.082	0.117	0.160	0.277	0.440	0.656



RECTANGLES

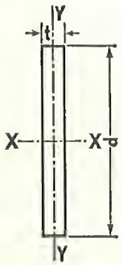
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
8	Wt.	1.210	1.815	2.420	3.025	3.630	4.235	4.840	5.445	6.050	7.260	8.470	9.680
	Area	1.000	1.500	2.000	2.500	3.000	3.500	4.000	4.500	5.000	6.000	7.000	8.000
	I x-x	5.333	8.000	10.67	13.33	16.00	18.67	21.33	24.00	26.67	32.00	37.33	42.67
	I y-y	0.001	0.004	0.010	0.020	0.035	0.056	0.083	0.119	0.163	0.281	0.447	0.667
8⅛	Wt.	1.229	1.843	2.458	3.072	3.687	4.301	4.916	5.530	6.145	7.373	8.602	9.831
	Area	1.016	1.523	2.031	2.539	3.047	3.555	4.063	4.570	5.078	6.094	7.109	8.125
	I x-x	5.587	8.381	11.17	13.97	16.76	19.56	22.35	25.14	27.94	33.52	39.11	44.70
	I y-y	0.001	0.004	0.011	0.021	0.036	0.057	0.085	0.121	0.165	0.286	0.454	0.677
8¼	Wt.	1.248	1.872	2.496	3.120	3.743	4.367	4.991	5.615	6.239	7.487	8.735	9.983
	Area	1.031	1.547	2.063	2.578	3.094	3.609	4.125	4.641	5.156	6.188	7.219	8.250
	I x-x	5.849	8.774	11.70	14.62	17.55	20.47	23.40	26.32	29.25	35.09	40.94	46.79
	I y-y	0.001	0.005	0.011	0.021	0.036	0.058	0.086	0.122	0.168	0.290	0.461	0.687
8⅜	Wt.	1.267	1.900	2.533	3.167	3.800	4.434	5.067	5.700	6.334	7.600	8.867	10.13
	Area	1.047	1.570	2.094	2.617	3.141	3.664	4.188	4.711	5.234	6.281	7.328	8.375
	I x-x	6.119	9.179	12.24	15.30	18.36	21.42	24.48	27.54	30.60	36.71	42.83	48.95
	I y-y	0.001	0.005	0.011	0.021	0.037	0.058	0.087	0.124	0.170	0.294	0.468	0.698
8½	Wt.	1.286	1.928	2.571	3.214	3.857	4.500	5.143	5.785	6.428	7.714	8.999	10.29
	Area	1.063	1.594	2.125	2.656	3.188	3.719	4.250	4.781	5.313	6.375	7.438	8.500
	I x-x	6.397	9.596	12.79	15.99	19.19	22.39	25.59	28.79	31.99	38.38	44.78	51.18
	I y-y	0.001	0.005	0.011	0.022	0.037	0.059	0.089	0.126	0.173	0.299	0.475	0.708
8⅝	Wt.	1.305	1.957	2.609	3.261	3.914	4.566	5.218	5.870	6.523	7.827	9.132	10.44
	Area	1.078	1.617	2.156	2.695	3.234	3.773	4.313	4.852	5.391	6.469	7.547	8.625
	I x-x	6.684	10.03	13.37	16.71	20.05	23.39	26.73	30.08	33.42	40.10	46.78	53.47
	I y-y	0.001	0.005	0.011	0.022	0.038	0.060	0.090	0.128	0.175	0.303	0.482	0.719
8¾	Wt.	1.323	1.985	2.647	3.309	3.970	4.632	5.294	5.955	6.617	7.941	9.264	10.59
	Area	1.094	1.641	2.188	2.734	3.281	3.828	4.375	4.922	5.469	6.563	7.656	8.750
	I x-x	6.978	10.47	13.96	17.45	20.94	24.42	27.91	31.40	34.89	41.87	48.85	55.83
	I y-y	0.001	0.005	0.011	0.022	0.038	0.061	0.091	0.130	0.178	0.308	0.488	0.729
8⅞	Wt.	1.342	2.014	2.685	3.356	4.027	4.698	5.369	6.041	6.712	8.054	9.396	10.74
	Area	1.109	1.664	2.219	2.773	3.328	3.883	4.438	4.992	5.547	6.656	7.766	8.875
	I x-x	7.282	10.92	14.56	18.20	21.85	25.49	29.13	32.77	36.41	43.69	50.97	58.25
	I y-y	0.001	0.005	0.012	0.023	0.039	0.062	0.092	0.132	0.181	0.312	0.495	0.740



RECTANGLES

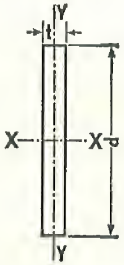
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
9	Wt.	1.361	2.042	2.723	3.403	4.084	4.764	5.445	6.126	6.806	8.168	9.529	10.89
	Area	1.125	1.688	2.250	2.813	3.375	3.938	4.500	5.063	5.625	6.750	7.875	9.000
	I x-x	7.594	11.39	15.19	18.98	22.78	26.58	30.38	34.17	37.97	45.56	53.16	60.75
	I y-y	0.001	0.005	0.012	0.023	0.040	0.063	0.094	0.133	0.183	0.316	0.502	0.750
9 1/8	Wt.	1.380	2.070	2.760	3.450	4.140	4.831	5.521	6.211	6.901	8.281	9.661	11.04
	Area	1.141	1.711	2.281	2.852	3.422	3.992	4.563	5.133	5.703	6.844	7.984	9.125
	I x-x	7.915	11.87	15.83	19.79	23.74	27.70	31.66	35.62	39.57	47.49	55.40	63.32
	I y-y	0.001	0.005	0.012	0.023	0.040	0.064	0.095	0.135	0.186	0.321	0.509	0.760
9 1/4	Wt.	1.399	2.099	2.798	3.498	4.197	4.897	5.596	6.296	6.995	8.394	9.793	11.19
	Area	1.156	1.734	2.313	2.891	3.469	4.047	4.625	5.203	5.781	6.938	8.094	9.250
	I x-x	8.244	12.37	16.49	20.61	24.73	28.86	32.98	37.10	41.22	49.47	57.71	65.95
	I y-y	0.002	0.005	0.012	0.024	0.041	0.065	0.096	0.137	0.188	0.325	0.516	0.771
9 3/8	Wt.	1.418	2.127	2.836	3.545	4.254	4.963	5.672	6.381	7.090	8.508	9.926	11.34
	Area	1.172	1.758	2.344	2.930	3.516	4.102	4.688	5.273	5.859	7.031	8.203	9.375
	I x-x	8.583	12.87	17.17	21.46	25.75	30.04	34.33	38.62	42.92	51.50	60.08	68.66
	I y-y	0.002	0.005	0.012	0.024	0.041	0.065	0.098	0.139	0.191	0.330	0.523	0.781
9 1/2	Wt.	1.437	2.155	2.874	3.592	4.311	5.029	5.748	6.466	7.184	8.621	10.06	11.50
	Area	1.188	1.781	2.375	2.969	3.563	4.156	4.750	5.344	5.938	7.125	8.313	9.500
	I x-x	8.931	13.40	17.86	22.33	26.79	31.26	35.72	40.19	44.66	53.59	62.52	71.45
	I y-y	0.002	0.005	0.012	0.024	0.042	0.066	0.099	0.141	0.193	0.334	0.530	0.792
9 5/8	Wt.	1.456	2.184	2.912	3.639	4.367	5.095	5.823	6.551	7.279	8.735	10.19	11.65
	Area	1.203	1.805	2.406	3.008	3.609	4.211	4.813	5.414	6.016	7.219	8.422	9.625
	I x-x	9.288	13.93	18.58	23.22	27.86	32.51	37.15	41.80	46.44	55.73	65.02	74.31
	I y-y	0.002	0.005	0.013	0.024	0.042	0.067	0.100	0.143	0.196	0.338	0.537	0.802
9 3/4	Wt.	1.475	2.212	2.949	3.687	4.424	5.161	5.899	6.636	7.373	8.848	10.32	11.80
	Area	1.219	1.828	2.438	3.047	3.656	4.266	4.875	5.484	6.094	7.313	8.531	9.750
	I x-x	9.655	14.48	19.31	24.14	28.96	33.79	38.62	43.45	48.27	57.93	67.58	77.24
	I y-y	0.002	0.005	0.013	0.025	0.043	0.068	0.102	0.145	0.198	0.343	0.544	0.812
9 7/8	Wt.	1.494	2.240	2.987	3.734	4.481	5.228	5.974	6.721	7.468	8.962	10.46	11.95
	Area	1.234	1.852	2.469	3.086	3.703	4.320	4.938	5.555	6.172	7.406	8.641	9.875
	I x-x	10.03	15.05	20.06	25.08	30.09	35.11	40.12	45.14	50.15	60.19	70.22	80.25
	I y-y	0.002	0.005	0.013	0.025	0.043	0.069	0.103	0.146	0.201	0.347	0.551	0.823



RECTANGLES

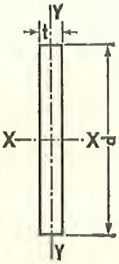
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\,d$; $r_{y\text{-}y}=0.289\,t$

Depth, d		Thickness, t											
		⅛	3⁄16	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1
10	Wt.	1.513	2.269	3.025	3.781	4.538	5.294	6.050	6.806	7.563	9.075	10.59	12.10
	Area	1.250	1.875	2.500	3.125	3.750	4.375	5.000	5.625	6.250	7.500	8.750	10.00
	I x-x	10.42	15.63	20.83	26.04	31.25	36.46	41.67	46.88	52.08	62.50	72.92	83.33
	I y-y	0.002	0.005	0.013	0.025	0.044	0.070	0.104	0.148	0.203	0.352	0.558	0.833
10⅛	Wt.	1.531	2.297	3.063	3.829	4.594	5.360	6.126	6.891	7.657	9.188	10.72	12.25
	Area	1.266	1.898	2.531	3.164	3.797	4.430	5.063	5.695	6.328	7.594	8.859	10.13
	I x-x	10.81	16.22	21.62	27.03	32.44	37.84	43.25	48.65	54.06	64.87	75.69	86.50
	I y-y	0.002	0.006	0.013	0.026	0.044	0.071	0.105	0.150	0.206	0.356	0.565	0.844
10¼	Wt.	1.550	2.325	3.101	3.876	4.651	5.426	6.201	6.976	7.752	9.302	10.85	12.40
	Area	1.281	1.922	2.563	3.203	3.844	4.484	5.125	5.766	6.406	7.688	8.969	10.25
	I x-x	11.22	16.83	22.44	28.04	33.65	39.26	44.87	50.48	56.09	67.31	78.52	89.74
	I y-y	0.002	0.006	0.013	0.026	0.045	0.072	0.107	0.152	0.209	0.360	0.572	0.854
10⅜	Wt.	1.569	2.354	3.138	3.923	4.708	5.492	6.277	7.061	7.846	9.415	10.98	12.55
	Area	1.297	1.945	2.594	3.242	3.891	4.539	5.188	5.836	6.484	7.781	9.078	10.38
	I x-x	11.63	17.45	23.27	29.08	34.90	40.72	46.53	52.35	58.17	69.80	81.43	93.06
	I y-y	0.002	0.006	0.014	0.026	0.046	0.072	0.108	0.154	0.211	0.365	0.579	0.865
10½	Wt.	1.588	2.382	3.176	3.970	4.764	5.558	6.353	7.147	7.941	9.529	11.12	12.71
	Area	1.313	1.969	2.625	3.281	3.938	4.594	5.250	5.906	6.563	7.875	9.188	10.50
	I x-x	12.06	18.09	24.12	30.15	36.18	42.21	48.23	54.26	60.29	72.35	84.41	96.47
	I y-y	0.002	0.006	0.014	0.027	0.046	0.073	0.109	0.156	0.214	0.369	0.586	0.875
10⅝	Wt.	1.607	2.411	3.214	4.018	4.821	5.625	6.428	7.232	8.035	9.642	11.25	12.86
	Area	1.328	1.992	2.656	3.320	3.984	4.648	5.313	5.977	6.641	7.969	9.297	10.63
	I x-x	12.49	18.74	24.99	31.24	37.48	43.73	49.98	56.22	62.47	74.97	87.46	99.95
	I y-y	0.002	0.006	0.014	0.027	0.047	0.074	0.111	0.158	0.216	0.374	0.593	0.885
10¾	Wt.	1.626	2.439	3.252	4.065	4.878	5.691	6.504	7.317	8.130	9.756	11.38	13.01
	Area	1.344	2.016	2.688	3.359	4.031	4.703	5.375	6.047	6.719	8.063	9.406	10.75
	I x-x	12.94	19.41	25.88	32.35	38.82	45.29	51.76	58.23	64.70	77.64	90.58	103.5
	I y-y	0.002	0.006	0.014	0.027	0.047	0.075	0.112	0.159	0.219	0.378	0.600	0.896
10⅞	Wt.	1.645	2.467	3.290	4.112	4.935	5.757	6.579	7.402	8.224	9.869	11.51	13.16
	Area	1.359	2.039	2.719	3.398	4.078	4.758	5.438	6.117	6.797	8.156	9.516	10.88
	I x-x	13.40	20.10	26.79	33.49	40.19	46.89	53.59	60.29	66.99	80.38	93.78	107.2
	I y-y	0.002	0.006	0.014	0.028	0.048	0.076	0.113	0.161	0.221	0.382	0.607	0.906



RECTANGLES

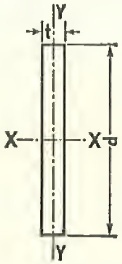
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
11	Wt.	1.664	2.496	3.328	4.159	4.991	5.823	6.655	7.487	8.319	9.983	11.65	13.31
	Area	1.375	2.063	2.750	3.438	4.125	4.813	5.500	6.188	6.875	8.250	9.625	11.00
	I x-x	13.86	20.80	27.73	34.66	41.59	48.53	55.46	62.39	69.32	83.19	97.05	110.9
	I y-y	0.002	0.006	0.014	0.028	0.048	0.077	0.115	0.163	0.224	0.387	0.614	0.917
11⅛	Wt.	1.683	2.524	3.365	4.207	5.048	5.889	6.731	7.572	8.413	10.10	11.78	13.46
	Area	1.391	2.086	2.781	3.477	4.172	4.867	5.563	6.258	6.953	8.344	9.734	11.13
	I x-x	14.34	21.51	28.69	35.86	43.03	50.20	57.37	64.54	71.71	86.06	100.4	114.7
	I y-y	0.002	0.006	0.014	0.028	0.049	0.078	0.116	0.165	0.226	0.391	0.621	0.927
11¼	Wt.	1.702	2.552	3.403	4.254	5.105	5.955	6.806	7.657	8.508	10.21	11.91	13.61
	Area	1.406	2.109	2.813	3.516	4.219	4.922	5.625	6.328	7.031	8.438	9.844	11.25
	I x-x	14.83	22.25	29.66	37.08	44.49	51.91	59.33	66.74	74.16	88.99	103.8	118.7
	I y-y	0.002	0.006	0.015	0.029	0.049	0.079	0.117	0.167	0.229	0.396	0.628	0.937
11⅜	Wt.	1.720	2.581	3.441	4.301	5.161	6.022	6.882	7.742	8.602	10.32	12.04	13.76
	Area	1.422	2.133	2.844	3.555	4.266	4.977	5.688	6.398	7.109	8.531	9.953	11.38
	I x-x	15.33	23.00	30.66	38.33	45.99	53.66	61.33	68.99	76.66	91.99	107.3	122.7
	I y-y	0.002	0.006	0.015	0.029	0.050	0.079	0.118	0.169	0.231	0.400	0.635	0.948
11½	Wt.	1.739	2.609	3.479	4.348	5.218	6.088	6.958	7.827	8.697	10.44	12.18	13.92
	Area	1.438	2.156	2.875	3.594	4.313	5.031	5.750	6.469	7.188	8.625	10.06	11.50
	I x-x	15.84	23.76	31.69	39.61	47.53	55.45	63.37	71.29	79.21	95.06	110.9	126.7
	I y-y	0.002	0.006	0.015	0.029	0.051	0.080	0.120	0.171	0.234	0.404	0.642	0.958
11⅝	Wt.	1.758	2.637	3.517	4.396	5.275	6.154	7.033	7.912	8.791	10.55	12.31	14.07
	Area	1.453	2.180	2.906	3.633	4.359	5.086	5.813	6.539	7.266	8.719	10.17	11.63
	I x-x	16.36	24.55	32.73	40.91	49.09	57.28	65.46	73.64	81.82	98.19	114.6	130.9
	I y-y	0.002	0.006	0.015	0.030	0.051	0.081	0.121	0.172	0.237	0.409	0.649	0.969
11¾	Wt.	1.777	2.666	3.554	4.443	5.332	6.220	7.109	7.997	8.886	10.66	12.44	14.22
	Area	1.469	2.203	2.938	3.672	4.406	5.141	5.875	6.609	7.344	8.813	10.28	11.75
	I x-x	16.90	25.35	33.80	42.25	50.69	59.14	67.59	76.04	84.49	101.4	118.3	135.2
	I y-y	0.002	0.006	0.015	0.030	0.052	0.082	0.122	0.174	0.239	0.413	0.656	0.979
11⅞	Wt.	1.796	2.694	3.592	4.490	5.388	6.286	7.184	8.082	8.980	10.78	12.57	14.37
	Area	1.484	2.227	2.969	3.711	4.453	5.195	5.938	6.680	7.422	8.906	10.39	11.88
	I x-x	17.44	26.17	34.89	43.61	52.33	61.05	69.77	78.49	87.22	104.7	122.1	139.5
	I y-y	0.002	0.007	0.015	0.030	0.052	0.083	0.124	0.176	0.242	0.417	0.663	0.990



RECTANGLES

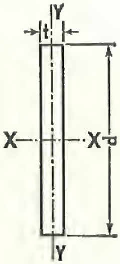
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289$ d; $r_{y\text{-}y}=0.289$ t

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
12	Wt.	1.815	2.723	3.630	4.538	5.445	6.353	7.260	8.168	9.075	10.89	12.71	14.52
	Area	1.500	2.250	3.000	3.750	4.500	5.250	6.000	6.750	7.500	9.000	10.50	12.00
	I x-x	18.00	27.00	36.00	45.00	54.00	63.00	72.00	81.00	90.00	108.0	126.0	144.0
	I y-y	0.002	0.007	0.016	0.031	0.053	0.084	0.125	0.178	0.244	0.422	0.670	1.000
12¼	Wt.	1.853	2.779	3.706	4.632	5.558	6.485	7.411	8.338	9.264	11.12	12.97	14.82
	Area	1.531	2.297	3.063	3.828	4.594	5.359	6.125	6.891	7.656	9.188	10.72	12.25
	I x-x	19.15	28.72	38.30	47.87	57.45	67.02	76.59	86.17	95.74	114.9	134.0	153.2
	I y-y	0.002	0.007	0.016	0.031	0.054	0.085	0.128	0.182	0.249	0.431	0.684	1.021
12½	Wt.	1.891	2.836	3.781	4.727	5.672	6.617	7.563	8.508	9.453	11.34	13.23	15.13
	Area	1.563	2.344	3.125	3.906	4.688	5.469	6.250	7.031	7.813	9.375	10.94	12.50
	I x-x	20.35	30.52	40.69	50.86	61.04	71.21	81.38	91.55	101.7	122.1	142.4	162.8
	I y-y	0.002	0.007	0.016	0.032	0.055	0.087	0.130	0.185	0.254	0.439	0.698	1.042
12¾	Wt.	1.928	2.893	3.857	4.821	5.785	6.750	7.714	8.678	9.642	11.57	13.50	15.43
	Area	1.594	2.391	3.188	3.984	4.781	5.578	6.375	7.172	7.969	9.563	11.16	12.75
	I x-x	21.59	32.39	43.18	53.98	64.77	75.57	86.36	97.16	108.0	129.5	151.1	172.7
	I y-y	0.002	0.007	0.017	0.032	0.056	0.089	0.133	0.189	0.259	0.448	0.712	1.062
13	Wt.	1.966	2.949	3.933	4.916	5.899	6.882	7.865	8.848	9.831	11.80	13.76	15.73
	Area	1.625	2.438	3.250	4.063	4.875	5.688	6.500	7.313	8.125	9.750	11.38	13.00
	I x-x	22.89	34.33	45.77	57.21	68.66	80.10	91.54	103.0	114.4	137.3	160.2	183.1
	I y-y	0.002	0.007	0.017	0.033	0.057	0.091	0.135	0.193	0.264	0.457	0.726	1.083
13¼	Wt.	2.004	3.006	4.008	5.010	6.012	7.014	8.016	9.018	10.02	12.02	14.03	16.03
	Area	1.656	2.484	3.313	4.141	4.969	5.797	6.625	7.453	8.281	9.938	11.59	13.25
	I x-x	24.23	36.35	48.46	60.58	72.69	84.81	96.93	109.0	121.2	145.4	169.6	193.9
	I y-y	0.002	0.007	0.017	0.034	0.058	0.092	0.138	0.197	0.270	0.466	0.740	1.104
13½	Wt.	2.042	3.063	4.084	5.105	6.126	7.147	8.168	9.188	10.21	12.25	14.29	16.34
	Area	1.688	2.531	3.375	4.219	5.063	5.906	6.750	7.594	8.438	10.13	11.81	13.50
	I x-x	25.63	38.44	51.26	64.07	76.89	89.70	102.5	115.3	128.1	153.8	179.4	205.0
	I y-y	0.002	0.007	0.018	0.034	0.059	0.094	0.141	0.200	0.275	0.475	0.754	1.125
13¾	Wt.	2.080	3.120	4.159	5.199	6.239	7.279	8.319	9.359	10.40	12.48	14.56	16.64
	Area	1.719	2.578	3.438	4.297	5.156	6.016	6.875	7.734	8.594	10.31	12.03	13.75
	I x-x	27.08	40.62	54.16	67.70	81.24	94.78	108.3	121.9	135.4	162.5	189.6	216.6
	I y-y	0.002	0.008	0.018	0.035	0.060	0.096	0.143	0.204	0.280	0.483	0.768	1.146



RECTANGLES

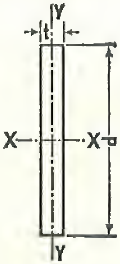
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		⅛	3⁄16	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1
14	Wt.	2.118	3.176	4.235	5.294	6.353	7.411	8.470	9.529	10.59	12.71	14.82	16.94
	Area	1.750	2.625	3.500	4.375	5.250	6.125	7.000	7.875	8.750	10.50	12.25	14.00
	I x-x	28.58	42.88	57.17	71.46	85.75	100.0	114.3	128.6	142.9	171.5	200.1	228.7
	I y-y	0.002	0.008	0.018	0.036	0.062	0.098	0.146	0.208	0.285	0.492	0.782	1.167
14¼	Wt.	2.155	3.233	4.311	5.388	6.466	7.544	8.621	9.699	10.78	12.93	15.09	17.24
	Area	1.781	2.672	3.563	4.453	5.344	6.234	7.125	8.016	8.906	10.69	12.47	14.25
	I x-x	30.14	45.21	60.28	75.36	90.43	105.5	120.6	135.6	150.7	180.9	211.0	241.1
	I y-y	0.002	0.008	0.019	0.036	0.063	0.099	0.148	0.211	0.290	0.501	0.796	1.187
14½	Wt.	2.193	3.290	4.386	5.483	6.579	7.676	8.773	9.869	10.97	13.16	15.35	17.55
	Area	1.813	2.719	3.625	4.531	5.438	6.344	7.250	8.156	9.063	10.88	12.69	14.50
	I x-x	31.76	47.63	63.51	79.39	95.27	111.1	127.0	142.9	158.8	190.5	222.3	254.1
	I y-y	0.002	0.008	0.019	0.037	0.064	0.101	0.151	0.215	0.295	0.510	0.809	1.208
14¾	Wt.	2.231	3.346	4.462	5.577	6.693	7.808	8.924	10.04	11.15	13.39	15.62	17.85
	Area	1.844	2.766	3.688	4.609	5.531	6.453	7.375	8.297	9.219	11.06	12.91	14.75
	I x-x	33.43	50.14	66.86	83.57	100.3	117.0	133.7	150.4	167.1	200.6	234.0	267.4
	I y-y	0.002	0.008	0.019	0.038	0.065	0.103	0.154	0.219	0.300	0.519	0.823	1.229
15	Wt.	2.269	3.403	4.538	5.672	6.806	7.941	9.075	10.21	11.34	13.61	15.88	18.15
	Area	1.875	2.813	3.750	4.688	5.625	6.563	7.500	8.438	9.375	11.25	13.13	15.00
	I x-x	35.16	52.73	70.31	87.89	105.5	123.0	140.6	158.2	175.8	210.9	246.1	281.3
	I y-y	0.002	0.008	0.020	0.038	0.066	0.105	0.156	0.222	0.305	0.527	0.837	1.250
15¼	Wt.	2.307	3.460	4.613	5.766	6.920	8.073	9.226	10.38	11.53	13.84	16.15	18.45
	Area	1.906	2.859	3.813	4.766	5.719	6.672	7.625	8.578	9.531	11.44	13.34	15.25
	I x-x	36.94	55.42	73.89	92.36	110.8	129.3	147.8	166.2	184.7	221.7	258.6	295.5
	I y-y	0.002	0.008	0.020	0.039	0.067	0.106	0.159	0.226	0.310	0.536	0.851	1.271
15½	Wt.	2.344	3.517	4.689	5.861	7.033	8.205	9.378	10.55	11.72	14.07	16.41	18.76
	Area	1.938	2.906	3.875	4.844	5.813	6.781	7.750	8.719	9.688	11.63	13.56	15.50
	I x-x	38.79	58.19	77.58	96.98	116.4	135.8	155.2	174.6	194.0	232.7	271.5	310.3
	I y-y	0.003	0.009	0.020	0.039	0.068	0.108	0.161	0.230	0.315	0.545	0.865	1.292
15¾	Wt.	2.382	3.573	4.764	5.955	7.147	8.338	9.529	10.72	11.91	14.29	16.68	19.06
	Area	1.969	2.953	3.938	4.922	5.906	6.891	7.875	8.859	9.844	11.81	13.78	15.75
	I x-x	40.70	61.05	81.40	101.7	122.1	142.4	162.8	183.1	203.5	244.2	284.9	325.6
	I y-y	0.003	0.009	0.021	0.040	0.069	0.110	0.164	0.234	0.320	0.554	0.879	1.312



RECTANGLES

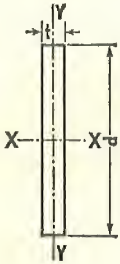
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
16	Wt.	2.420	3.630	4.840	6.050	7.260	8.470	9.680	10.89	12.10	14.52	16.94	19.36
	Area	2.000	3.000	4.000	5.000	6.000	7.000	8.000	9.000	10.00	12.00	14.00	16.00
	I x-x	42.67	64.00	85.33	106.7	128.0	149.3	170.7	192.0	213.3	256.0	298.7	341.3
	I y-y	0.003	0.009	0.021	0.041	0.070	0.112	0.167	0.237	0.326	0.562	0.893	1.333
16¼	Wt.	2.458	3.687	4.916	6.145	7.373	8.602	9.831	11.06	12.29	14.75	17.20	19.66
	Area	2.031	3.047	4.063	5.078	6.094	7.109	8.125	9.141	10.16	12.19	14.22	16.25
	I x-x	44.70	67.05	89.40	111.7	134.1	156.4	178.8	201.1	223.5	268.2	312.9	357.6
	I y-y	0.003	0.009	0.021	0.041	0.071	0.113	0.169	0.241	0.331	0.571	0.907	1.354
16½	Wt.	2.496	3.743	4.991	6.239	7.487	8.735	9.983	11.23	12.48	14.97	17.47	19.97
	Area	2.063	3.094	4.125	5.156	6.188	7.219	8.250	9.281	10.31	12.38	14.44	16.50
	I x-x	46.79	70.19	93.59	117.0	140.4	163.8	187.2	210.6	234.0	280.8	327.6	374.3
	I y-y	0.003	0.009	0.021	0.042	0.073	0.115	0.172	0.245	0.336	0.580	0.921	1.375
16¾	Wt.	2.533	3.800	5.067	6.334	7.600	8.867	10.13	11.40	12.67	15.20	17.73	20.27
	Area	2.094	3.141	4.188	5.234	6.281	7.328	8.375	9.422	10.47	12.56	14.66	16.75
	I x-x	48.95	73.43	97.90	122.4	146.9	171.3	195.8	220.3	244.8	293.7	342.7	391.6
	I y-y	0.003	0.009	0.022	0.043	0.074	0.117	0.174	0.248	0.341	0.589	0.935	1.396
17	Wt.	2.571	3.857	5.143	6.428	7.714	8.999	10.29	11.57	12.86	15.43	18.00	20.57
	Area	2.125	3.188	4.250	5.313	6.375	7.438	8.500	9.563	10 63	12.75	14.88	17.00
	I x-x	51.18	76.77	102.4	127.9	153.5	179.1	204.7	230.3	255.9	307.1	358.2	409.4
	I y-y	0.003	0.009	0.022	0.043	0.075	0.119	0.177	0.252	0.346	0.598	0.949	1.417
17¼	Wt.	2.609	3.914	5.218	6.523	7.827	9.132	10.44	11.74	13.05	15.65	18.26	20.87
	Area	2.156	3.234	4.313	5.391	6.469	7.547	8.625	9.703	10.78	12.94	15.09	17.25
	I x-x	53.47	80.20	106.9	133.7	160.4	187.1	213.9	240.6	267.3	320.8	374.3	427.7
	I y-y	0.003	0.009	0.022	0.044	0.076	0.120	0.180	0.256	0.351	0.606	0.963	1.437
17½	Wt.	2.647	3.970	5.294	6.617	7.941	9.264	10.59	11.91	13 23	15.88	18.53	21.18
	Area	2.188	3.281	4.375	5.469	6.563	7.656	8.750	9.844	10.94	13.13	15.31	17.50
	I x-x	55.83	83.74	111.7	139.6	167.5	195.4	223.3	251.2	279.1	335.0	390.8	446.6
	I y-y	0.003	0.010	0.023	0.045	0.077	0.122	0.182	0.260	0.356	0.615	0.977	1.458
17¾	Wt.	2.685	4.027	5.369	6.712	8.054	9.396	10.74	12 08	13.42	16.11	18.79	21.48
	Area	2.219	3.328	4.438	5.547	6.656	7.766	8.875	9.984	11.09	13.31	15.53	17.75
	I x-x	58.25	87.38	116.5	145.6	174.8	203.9	233.0	262.1	291.3	349.5	407.8	466.0
	I y-y	0.003	0.010	0.023	0.045	0.078	0.124	0.185	0.263	0.361	0.624	0.991	1.479



RECTANGLES

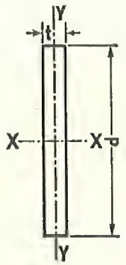
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
18	Wt.	2.723	4.084	5.445	6.806	8.168	9.529	10.89	12.25	13.61	16.34	19.06	21.78
	Area	2.250	3.375	4.500	5.625	6.750	7.875	9.000	10.13	11.25	13.50	15.75	18.00
	I x-x	60.75	91.13	121.5	151.9	182.3	212.6	243.0	273.4	303.8	364.5	425.3	486.0
	I y-y	0.003	0.010	0.023	0.046	0.079	0.126	0.188	0.267	0.366	0.633	1.005	1.500
18¼	Wt.	2.760	4.140	5.521	6.901	8.281	9.661	11.04	12.42	13.80	16.56	19.32	22.08
	Area	2.281	3.422	4.563	5.703	6.844	7.984	9.125	10.27	11.41	13.69	15.97	18.25
	I x-x	63.32	94.97	126.6	158.3	189.9	221.6	253.3	284.9	316.6	379.9	443.2	506.5
	I y-y	0.003	0.010	0.024	0.046	0.080	0.127	0.190	0.271	0.371	0.642	1.019	1.521
18½	Wt.	2.798	4.197	5.596	6.995	8.394	9.793	11.19	12.59	13.99	16.79	19.59	22.39
	Area	2.313	3.469	4.625	5.781	6.938	8.094	9.250	10.41	11.56	13.88	16.19	18.50
	I x-x	65.95	98.93	131.9	164.9	197.9	230.8	263.8	296.8	329.8	395.7	461.7	527.6
	I y-y	0.003	0.010	0.024	0.047	0.081	0.129	0.193	0.274	0.376	0.650	1.033	1.542
18¾	Wt.	2.836	4.254	5.672	7.090	8.508	9.926	11.34	12.76	14.18	17.02	19.85	22.69
	Area	2.344	3.516	4.688	5.859	7.031	8.203	9.375	10.55	11.72	14.06	16.41	18.75
	I x-x	68.66	103.0	137.3	171.7	206.0	240.3	274.7	309.0	343.3	412.0	480.7	549.3
	I y-y	0.003	0.010	0.024	0.048	0.082	0.131	0.195	0.278	0.381	0.659	1.047	1.562
19	Wt.	2.874	4.311	5.748	7.184	8.621	10.06	11.50	12.93	14.37	17.24	20.12	22.99
	Area	2.375	3.563	4.750	5.938	7.125	8.313	9.500	10.69	11.88	14.25	16.63	19.00
	I x-x	71.45	107.2	142.9	178.6	214.3	250.1	285.8	321.5	357.2	428.7	500.1	571.6
	I y-y	0.003	0.010	0.025	0.048	0.083	0.133	0.198	0.282	0.387	0.668	1.061	1.583
19¼	Wt.	2.912	4.367	5.823	7.279	8.735	10.19	11.65	13.10	14.56	17.47	20.38	23.29
	Area	2.406	3.609	4.813	6.016	7.219	8.422	9.625	10.83	12.03	14.44	16.84	19.25
	I x-x	74.31	111.5	148.6	185.8	222.9	260.1	297.2	334.4	371.5	445.8	520.1	594.4
	I y-y	0.003	0.011	0.025	0.049	0.085	0.134	0.201	0.286	0.392	0.677	1.075	1.604
19½	Wt.	2.949	4.424	5.899	7.373	8.848	10.32	11.80	13.27	14.75	17.70	20.65	23.60
	Area	2.438	3.656	4.875	6.094	7.313	8.531	9.750	10.97	12.19	14.63	17.06	19.50
	I x-x	77.24	115.9	154.5	193.1	231.7	270.3	309.0	347.6	386.2	463.4	540.7	617.9
	I y-y	0.003	0.011	0.025	0.050	0.086	0.136	0.203	0.289	0.397	0.686	1.089	1.625
19¾	Wt.	2.987	4.481	5.974	7.468	8.962	10.46	11.95	13.44	14.94	17.92	20.91	23.90
	Area	2.469	3.703	4.938	6.172	7.406	8.641	9.875	11.11	12.34	14.81	17.28	19.75
	I x-x	80.25	120.4	160.5	200.6	240.7	280.9	321.0	361.1	401.2	481.5	561.7	642.0
	I y-y	0.003	0.011	0.026	0.050	0.087	0.138	0.206	0.293	0.402	0.694	1.103	1.646



RECTANGLES

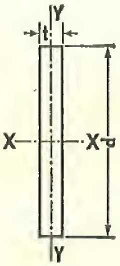
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
20	Wt.	3.025	4.538	6.050	7.563	9.075	10.59	12.10	13.61	15.13	18.15	21.18	24.20
	Area	2.500	3.750	5.000	6.250	7.500	8.750	10.00	11.25	12.50	15.00	17.50	20.00
	I x-x	83.33	125.0	166.7	208.3	250.0	291.7	333.3	375.0	416.7	500.0	583.3	666.7
	I y-y	0.003	0.011	0.026	0.051	0.088	0.140	0.208	0.297	0.407	0.703	1.117	1.667
20 1/4	Wt.	3.063	4.594	6.126	7.657	9.188	10.72	12.25	13.78	15.31	18.38	21.44	24.50
	Area	2.531	3.797	5.063	6.328	7.594	8.859	10.13	11.39	12.66	15.19	17.72	20.25
	I x-x	86.50	129.7	173.0	216.2	259.5	302.7	346.0	389.2	432.5	519.0	605.5	692.0
	I y-y	0.003	0.011	0.026	0.051	0.089	0.141	0.211	0.300	0.412	0.712	1.130	1.687
20 1/2	Wt.	3.101	4.651	6.201	7.752	9.302	10.85	12.40	13.95	15.50	18.60	21.71	24.81
	Area	2.563	3.844	5.125	6.406	7.688	8.969	10.25	11.53	12.81	15.38	17.94	20.50
	I x-x	89.74	134.6	179.5	224.4	269.2	314.1	359.0	403.8	448.7	538.4	628.2	717.9
	I y-y	0.003	0.011	0.027	0.052	0.090	0.143	0.214	0.304	0.417	0.721	1.144	1.708
20 3/4	Wt.	3.138	4.708	6.277	7.846	9.415	10.98	12.55	14.12	15.69	18.83	21.97	25.11
	Area	2.594	3.891	5.188	6.484	7.781	9.078	10.38	11.67	12.97	15.56	18.16	20.75
	I x-x	93.06	139.6	186.1	232.7	279.2	325.7	372.3	418.8	465.3	558.4	651.5	744.5
	I y-y	0.003	0.011	0.027	0.053	0.091	0.145	0.216	0.308	0.422	0.729	1.158	1.729
21	Wt.	3.176	4.764	6.353	7.941	9.529	11.12	12.71	14.29	15.88	19.06	22.23	25.41
	Area	2.625	3.938	5.250	6.563	7.875	9.188	10.50	11.81	13.13	15.75	18.38	21.00
	I x-x	96.47	144.7	192.9	241.2	289.4	337.6	385.9	434.1	482.3	578.8	675.3	771.8
	I y-y	0.003	0.012	0.027	0.053	0.092	0.147	0.219	0.311	0.427	0.738	1.172	1.750
21 1/4	Wt.	3.214	4.821	6.428	8.035	9.642	11.25	12.86	14.46	16.07	19.28	22.50	25.71
	Area	2.656	3.984	5.313	6.641	7.969	9.297	10.63	11.95	13.28	15.94	18.59	21.25
	I x-x	99.96	149.9	199.9	249.9	299.9	349.8	399.8	449.8	499.8	599.7	699.7	799.6
	I y-y	0.003	0.012	0.028	0.054	0.093	0.148	0.221	0.315	0.432	0.747	1.186	1.771
21 1/2	Wt.	3.252	4.878	6.504	8.130	9.756	11.38	13.01	14.63	16.26	19.51	22.76	26.02
	Area	2.688	4.031	5.375	6.719	8.063	9.406	10.75	12.09	13.44	16.13	18.81	21.50
	I x-x	103.5	155.3	207.1	258.8	310.6	362.3	414.1	465.9	517.6	621.1	724.7	828.2
	I y-y	0.003	0.012	0.028	0.055	0.094	0.150	0.224	0.319	0.437	0.756	1.200	1.792
21 3/4	Wt.	3.290	4.935	6.579	8.224	9.869	11.51	13.16	14.80	16.45	19.74	23.03	26.32
	Area	2.719	4.078	5.438	6.797	8.156	9.516	10.88	12.23	13.59	16.31	19.03	21.75
	I x-x	107.2	160.8	214.4	267.9	321.5	375.1	428.7	482.3	535.9	643.1	750.2	857.4
	I y-y	0.004	0.012	0.028	0.055	0.096	0.152	0.227	0.323	0.443	0.765	1.214	1.812



RECTANGLES

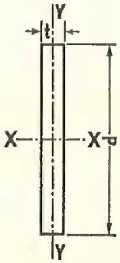
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
22	Wt.	3.328	4.991	6.655	8.319	9.983	11.65	13.31	14.97	16.64	19.97	23.29	26.62
	Area	2.750	4.125	5.500	6.875	8.250	9.625	11.00	12.38	13.75	16.50	19.25	22.00
	I x-x	110.9	166.4	221.8	277.3	332.8	388.2	443.7	499.1	554.6	665.5	776.4	887.3
	I y-y	0.004	0.012	0.029	0.056	0.097	0.154	0.229	0.326	0.448	0.773	1.228	1.833
22¼	Wt.	3.365	5.048	6.731	8.413	10.10	11.78	13.46	15.14	16.83	20.19	23.56	26.92
	Area	2.781	4.172	5.563	6.953	8.344	9.734	11.13	12.52	13.91	16.69	19.47	22.25
	I x-x	114.7	172.1	229.5	286.8	344.2	401.6	459.0	516.3	573.7	688.4	803.2	917.9
	I y-y	0.004	0.012	0.029	0.057	0.098	0.155	0.232	0.330	0.453	0.782	1.242	1.854
22½	Wt.	3.403	5.105	6.806	8.508	10.21	11.91	13.61	15.31	17.02	20.42	23.82	27.23
	Area	2.813	4.219	5.625	7.031	8.438	9.844	11.25	12.66	14.06	16.88	19.69	22.50
	I x-x	118.7	178.0	237.3	296.6	356.0	415.3	474.6	534.0	593.3	711.9	830.6	949.3
	I y-y	0.004	0.012	0.029	0.057	0.099	0.157	0.234	0.334	0.458	0.791	1.256	1.875
22¾	Wt.	3.441	5.161	6.882	8.602	10.32	12.04	13.76	15.48	17.20	20.65	24.09	27.53
	Area	2.844	4.266	5.688	7.109	8.531	9.953	11.38	12.80	14.22	17.06	19.91	22.75
	I x-x	122.7	184.0	245.3	306.6	368.0	429.3	490.6	552.0	613.3	735.9	858.6	981.3
	I y-y	0.004	0.012	0.030	0.058	0.100	0.159	0.237	0.337	0.463	0.800	1.270	1.896
23	Wt.	3.479	5.218	6.958	8.697	10.44	12.18	13.92	15.65	17.39	20.87	24.35	27.83
	Area	2.875	4.313	5.750	7.188	8.625	10.06	11.50	12.94	14.38	17.25	20.13	23.00
	I x-x	126.7	190.1	253.5	316.8	380.2	443.6	507.0	570.3	633.7	760.4	887.2	1014.
	I y-y	0.004	0.013	0.030	0.058	0.101	0.161	0.240	0.341	0.468	0.809	1.284	1.917
23¼	Wt.	3.517	5.275	7.033	8.791	10.55	12.31	14.07	15.82	17.58	21.10	24.62	28.13
	Area	2.906	4.359	5.813	7.266	8.719	10.17	11.63	13.08	14.53	17.44	20.34	23.25
	I x-x	130.9	196.4	261.8	327.3	392.8	458.2	523.7	589.1	654.6	785.5	916.4	1047.
	I y-y	0.004	0.013	0.030	0.059	0.102	0.162	0.242	0.345	0.473	0.817	1.298	1.937
23½	Wt.	3.554	5.332	7.109	8.886	10.66	12.44	14.22	15.99	17.77	21.33	24.88	28.44
	Area	2.938	4.406	5.875	7.344	8.813	10.28	11.75	13.22	14.69	17.63	20.56	23.50
	I x-x	135.2	202.8	270.4	338.0	405.6	473.2	540.8	608.3	675.9	811.1	946.3	1082.
	I y-y	0.004	0.013	0.031	0.060	0.103	0.164	0.245	0.349	0.478	0.826	1.312	1.958
23¾	Wt.	3.592	5.388	7.184	8.980	10.78	12.57	14.37	16.16	17.96	21.55	25.15	28.74
	Area	2.969	4.453	5.938	7.422	8.906	10.39	11.88	13.36	14.84	17.81	20.78	23.75
	I x-x	139.5	209.3	279.1	348.9	418.6	488.4	558.2	627.9	697.7	837.3	976.8	1116.
	I y-y	0.004	0.013	0.031	0.060	0.104	0.166	0.247	0.352	0.483	0.835	1.326	1.979



RECTANGLES

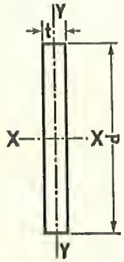
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
24	Wt.	3.630	5.445	7.260	9.075	10.89	12.71	14.52	16.34	18.15	21.78	25.41	29.04
	Area	3.000	4.500	6.000	7.500	9.000	10.50	12.00	13.50	15.00	18.00	21.00	24.00
	I x-x	144.0	216.0	288.0	360.0	432.0	504.0	576.0	648.0	720.0	864.0	1008.	1152.
	I y-y	0.004	0.013	0.031	0.061	0.105	0.167	0.250	0.356	0.488	0.844	1.340	2.000
24½	Wt.	3.706	5.558	7.411	9.264	11.12	12.97	14.82	16.68	18.53	22.23	25.94	29.65
	Area	3.063	4.594	6.125	7.656	9.188	10.72	12.25	13.78	15.31	18.38	21.44	24.50
	I x-x	153.2	229.8	306.4	383.0	459.6	536.2	612.8	689.3	765.9	919.1	1072.	1226.
	I y-y	0.004	0.013	0.032	0.062	0.108	0.171	0.255	0.363	0.498	0.861	1.368	2.042
25	Wt.	3.781	5.672	7.563	9.453	11.34	13.23	15.13	17.02	18.91	22.69	26.47	30.25
	Area	3.125	4.688	6.250	7.813	9.375	10.94	12.50	14.06	15.63	18.75	21.88	25.00
	I x-x	162.8	244.1	325.5	406.9	488.3	569.7	651.0	732.4	813.8	976.6	1139.	1302.
	I y-y	0.004	0.014	0.033	0.064	0.110	0.174	0.260	0.371	0.509	0.879	1.396	2.083
25½	Wt.	3.857	5.785	7.714	9.642	11.57	13.50	15.43	17.36	19.28	23.14	27.00	30.86
	Area	3.188	4.781	6.375	7.969	9.563	11.16	12.75	14.34	15.94	19.13	22.31	25.50
	I x-x	172.7	259.1	345.4	431.8	518.2	604.5	690.9	777.2	863.6	1036.	1209.	1382.
	I y-y	0.004	0.014	0.033	0.065	0.112	0.178	0.266	0.378	0.519	0.896	1.424	2.125
26	Wt.	3.933	5.899	7.865	9.831	11.80	13.76	15.73	17.70	19.66	23.60	27.53	31.46
	Area	3.250	4.875	6.500	8.125	9.750	11.38	13.00	14.63	16.25	19.50	22.75	26.00
	I x-x	183.1	274.6	366.2	457.7	549.3	640.8	732.3	823.9	915.4	1099.	1282.	1465.
	I y-y	0.004	0.014	0.034	0.066	0.114	0.181	0.271	0.386	0.529	0.914	1.452	2.167
26½	Wt.	4.008	6.012	8.016	10.02	12.02	14.03	16.03	18.04	20.04	24.05	28.06	32.07
	Area	3.313	4.969	6.625	8.281	9.938	11.59	13.25	14.91	16.56	19.88	23.19	26.50
	I x-x	193.9	290.8	387.7	484.6	581.6	678.5	775.4	872.3	969.3	1163.	1357.	1551.
	I y-y	0.004	0.015	0.035	0.067	0.116	0.185	0.276	0.393	0.539	0.932	1.479	2.208
27	Wt.	4.084	6.126	8.168	10.21	12.25	14.29	16.34	18.38	20.42	24.50	28.59	32.67
	Area	3.375	5.063	6.750	8.438	10.13	11.81	13.50	15.19	16.88	20.25	23.63	27.00
	I x-x	205.0	307.5	410.1	512.6	615.1	717.6	820.1	922.6	1025.	1230.	1435.	1640.
	I y-y	0.004	0.015	0.035	0.069	0.119	0.188	0.281	0.400	0.549	0.949	1.507	2.250
27½	Wt.	4.159	6.239	8.319	10.40	12.48	14.56	16.64	18.72	20.80	24.96	29.12	33.28
	Area	3.438	5.156	6.875	8.594	10.31	12.03	13.75	15.47	17.19	20.63	24.06	27.50
	I x-x	216.6	325.0	433.3	541.6	649.9	758.2	866.5	974.9	1083.	1300.	1516.	1733.
	I y-y	0.004	0.015	0.036	0.070	0.121	0.192	0.286	0.408	0.559	0.967	1.535	2.292



RECTANGLES

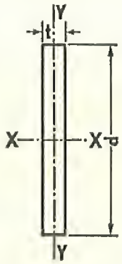
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
28	Wt.	4.235	6.353	8.470	10.59	12.71	14.82	16.94	19.06	21.18	25.41	29.65	33.88
	Area	3.500	5.250	7.000	8.750	10.50	12.25	14.00	15.75	17.50	21.00	24.50	28.00
	I x-x	228.7	343.0	457.3	571.7	686.0	800.3	914.7	1029.	1143.	1372.	1601.	1829.
	I y-y	0.005	0.015	0.036	0.071	0.123	0.195	0.292	0.415	0.570	0.984	1.563	2.333
28½	Wt.	4.311	6.466	8.621	10.78	12.93	15.09	17.24	19.40	21.55	25.86	30.17	34.49
	Area	3.563	5.344	7.125	8.906	10.69	12.47	14.25	16.03	17.81	21.38	24.94	28.50
	I x-x	241.1	361.7	482.3	602.8	723.4	844.0	964.5	1085.	1206.	1447.	1688.	1929.
	I y-y	0.005	0.016	0.037	0.072	0.125	0.199	0.297	0.423	0.580	1.002	1.591	2.375
29	Wt.	4.386	6.579	8.773	10.97	13.16	15.35	17.55	19.74	21.93	26.32	30.70	35.09
	Area	3.625	5.438	7.250	9.063	10.88	12.69	14.50	16.31	18.13	21.75	25.38	29.00
	I x-x	254.1	381.1	508.1	635.1	762.2	889.2	1016.	1143.	1270.	1524.	1778.	2032.
	I y-y	0.005	0.016	0.038	0.074	0.127	0.202	0.302	0.430	0.590	1.020	1.619	2.417
29½	Wt.	4.462	6.693	8.924	11.15	13.39	15.62	17.85	20.08	22.31	26.77	31.23	35.70
	Area	3.688	5.531	7.375	9.219	11.06	12.91	14.75	16.59	18.44	22.13	25.81	29.50
	I x-x	267.4	401.1	534.8	668.5	802.3	936.0	1070.	1203.	1337.	1605.	1872.	2139.
	I y-y	0.005	0.016	0.038	0.075	0.130	0.206	0.307	0.438	0.600	1.037	1.647	2.458
30	Wt.	4.538	6.806	9.075	11.34	13.61	15.88	18.15	20.42	22.69	27.23	31.76	36.30
	Area	3.750	5.625	7.500	9.375	11.25	13.13	15.00	16.88	18.75	22.50	26.25	30.00
	I x-x	281.3	421.9	562.5	703.1	843.8	984.4	1125.	1266.	1406.	1688.	1969.	2250.
	I y-y	0.005	0.016	0.039	0.076	0.132	0.209	0.313	0.445	0.610	1.055	1.675	2.500
30½	Wt.	4.613	6.920	9.226	11.53	13.84	16.15	18.45	20.76	23.07	27.68	32.29	36.91
	Area	3.813	5.719	7.625	9.531	11.44	13.34	15.25	17.16	19.06	22.88	26.69	30.50
	I x-x	295.6	443.3	591.1	738.9	886.7	1034.	1182.	1330.	1478.	1773.	2069.	2364.
	I y-y	0.005	0.017	0.040	0.078	0.134	0.213	0.318	0.452	0.621	1.072	1.703	2.542
31	Wt.	4.689	7.033	9.378	11.72	14.07	16.41	18.76	21.10	23.44	28.13	32.82	37.51
	Area	3.875	5.813	7.750	9.688	11.63	13.56	15.50	17.44	19.38	23.25	27.13	31.00
	I x-x	310.3	465.5	620.6	775.8	931.0	1086.	1241.	1396.	1552.	1862.	2172.	2483.
	I y-y	0.005	0.017	0.040	0.079	0.136	0.216	0.323	0.460	0.631	1.090	1.731	2.583
31½	Wt.	4.764	7.147	9.529	11.91	14.29	16.68	19.06	21.44	23.82	28.59	33.35	38.12
	Area	3.938	5.906	7.875	9.844	11.81	13.78	15.75	17.72	19.69	23.63	27.56	31.50
	I x-x	325.6	488.4	651.2	814.0	976.8	1140.	1302.	1465.	1628.	1954.	2279.	2605.
	I y-y	0.005	0.017	0.041	0.080	0.138	0.220	0.328	0.467	0.641	1.107	1.759	2.625



RECTANGLES

ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
32	Wt.	4.840	7.260	9.680	12.10	14.52	16.94	19.36	21.78	24.20	29.04	33.88	38.72
	Area	4.000	6.000	8.000	10.00	12.00	14.00	16.00	18.00	20.00	24.00	28.00	32.00
	I x-x	341.3	512.0	682.7	853.3	1024.	1195.	1365.	1536.	1707.	2048.	2389.	2731.
	I y-y	0.005	0.018	0.042	0.081	0.141	0.223	0.333	0.475	0.651	1.125	1.786	2.667
32½	Wt.	4.916	7.373	9.831	12.29	14.75	17.20	19.66	22.12	24.58	29.49	34.41	39.33
	Area	4.063	6.094	8.125	10.16	12.19	14.22	16.25	18.28	20.31	24.38	28.44	32.50
	I x-x	357.6	536.4	715.2	894.0	1073.	1252.	1430.	1609.	1788.	2146.	2503.	2861.
	I y-y	0.005	0.018	0.042	0.083	0.143	0.227	0.339	0.482	0.661	1.143	1.814	2.708
33	Wt.	4.991	7.487	9.983	12.48	14.97	17.47	19.97	22.46	24.96	29.95	34.94	39.93
	Area	4.125	6.188	8.250	10.31	12.38	14.44	16.50	18.56	20.63	24.75	28.88	33.00
	I x-x	374.3	561.5	748.7	935.9	1123.	1310.	1497.	1685.	1872.	2246.	2620.	2995.
	I y-y	0.005	0.018	0.043	0.084	0.145	0.230	0.344	0.489	0.671	1.160	1.842	2.750
33½	Wt.	5.067	7.600	10.13	12.67	15.20	17.73	20.27	22.80	25.33	30.40	35.47	40.54
	Area	4.188	6.281	8.375	10.47	12.56	14.66	16.75	18.84	20.94	25.13	29.31	33.50
	I x-x	391.6	587.4	783.2	979.0	1175.	1371.	1566.	1762.	1958.	2350.	2741.	3133.
	I y-y	0.005	0.018	0.044	0.085	0.147	0.234	0.349	0.497	0.682	1.178	1.870	2.792
34	Wt.	5.143	7.714	10.29	12.86	15.43	18.00	20.57	23.14	25.71	30.86	36.00	41.14
	Area	4.250	6.375	8.500	10.63	12.75	14.88	17.00	19.13	21.25	25.50	29.75	34.00
	I x-x	409.4	614.1	818.8	1024.	1228.	1433.	1638.	1842.	2047.	2457.	2866.	3275.
	I y-y	0.006	0.019	0.044	0.086	0.149	0.237	0.354	0.504	0.692	1.195	1.898	2.833
34½	Wt.	5.218	7.827	10.44	13.05	15.65	18.26	20.87	23.48	26.09	31.31	36.53	41.75
	Area	4.313	6.469	8.625	10.78	12.94	15.09	17.25	19.41	21.56	25.88	30.19	34.50
	I x-x	427.8	641.6	855.5	1069.	1283.	1497.	1711.	1925.	2139.	2567.	2994.	3422.
	I y-y	0.006	0.019	0.045	0.088	0.152	0.241	0.359	0.512	0.702	1.213	1.926	2.875
35	Wt.	5.294	7.941	10.59	13.23	15.88	18.53	21.18	23.82	26.47	31.76	37.06	42.35
	Area	4.375	6.563	8.750	10.94	13.13	15.31	17.50	19.69	21.88	26.25	30.63	35.00
	I x-x	446.6	669.9	893.2	1117.	1340.	1563.	1786.	2010.	2233.	2680.	3126.	3573.
	I y-y	0.006	0.019	0.046	0.089	0.154	0.244	0.365	0.519	0.712	1.230	1.954	2.917
35½	Wt.	5.369	8.054	10.74	13.42	16.11	18.79	21.48	24.16	26.85	32.22	37.59	42.96
	Area	4.438	6.656	8.875	11.09	13.31	15.53	17.75	19.97	22.19	26.63	31.06	35.50
	I x-x	466.0	699.0	932.1	1165.	1398.	1631.	1864.	2097.	2330.	2796.	3262.	3728.
	I y-y	0.006	0.020	0.046	0.090	0.156	0.248	0.370	0.527	0.722	1.248	1.982	2.958

RECTANGLES

ELEMENTS OF SECTIONS

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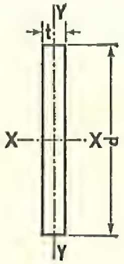
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
36	Wt.	5.445	8.168	10.89	13.61	16.34	19.06	21.78	24.50	27.23	32.67	38.12	43.56
	Area	4.500	6.750	9.000	11.25	13.50	15.75	18.00	20.25	22.50	27.00	31.50	36.00
	I x-x	486.0	729.0	972.0	1215.	1458.	1701.	1944.	2187.	2430.	2916.	3402.	3888.
	I y-y	0.006	0.020	0.047	0.092	0.158	0.251	0.375	0.534	0.732	1.266	2.010	3.000
36½	Wt.	5.521	8.281	11.04	13.80	16.56	19.32	22.08	24.84	27.60	33.12	38.64	44.17
	Area	4.563	6.844	9.125	11.41	13.69	15.97	18.25	20.53	22.81	27.38	31.94	36.50
	I x-x	506.5	759.8	1013.	1266.	1520.	1773.	2026.	2279.	2533.	3039.	3546.	4052.
	I y-y	0.006	0.020	0.048	0.093	0.160	0.255	0.380	0.541	0.743	1.283	2.038	3.042
37	Wt.	5.596	8.394	11.19	13.99	16.79	19.59	22.39	25.18	27.98	33.58	39.17	44.77
	Area	4.625	6.938	9.250	11.56	13.88	16.19	18.50	20.81	23.13	27.75	32.38	37.00
	I x-x	527.6	791.5	1055.	1319.	1583.	1847.	2111.	2374.	2638.	3166.	3693.	4221.
	I y-y	0.006	0.020	0.048	0.094	0.163	0.258	0.385	0.549	0.753	1.301	2.066	3.083
37½	Wt.	5.672	8.508	11.34	14.18	17.02	19.85	22.69	25.52	28.36	34.03	39.70	45.38
	Area	4.688	7.031	9.375	11.72	14.06	16.41	18.75	21.09	23.44	28.13	32.81	37.50
	I x-x	549.3	824.0	1099.	1373.	1648.	1923.	2197.	2472.	2747.	3296.	3845.	4395.
	I y-y	0.006	0.021	0.049	0.095	0.165	0.262	0.391	0.556	0.763	1.318	2.094	3.125
38	Wt.	5.748	8.621	11.50	14.37	17.24	20.12	22.99	25.86	28.74	34.49	40.23	45.98
	Area	4.750	7.125	9.500	11.88	14.25	16.63	19.00	21.38	23.75	28.50	33.25	38.00
	I x-x	571.6	857.4	1143.	1429.	1715.	2001.	2286.	2572.	2858.	3430.	4001.	4573.
	I y-y	0.006	0.021	0.049	0.097	0.167	0.265	0.396	0.564	0.773	1.336	2.121	3.167
38½	Wt.	5.823	8.735	11.65	14.56	17.47	20.38	23.29	26.20	29.12	34.94	40.76	46.59
	Area	4.813	7.219	9.625	12.03	14.44	16.84	19.25	21.66	24.06	28.88	33.69	38.50
	I x-x	594.4	891.7	1189.	1486.	1783.	2081.	2378.	2675.	2972.	3567.	4161.	4756.
	I y-y	0.006	0.021	0.050	0.098	0.169	0.269	0.401	0.571	0.783	1.354	2.149	3.208
39	Wt.	5.899	8.848	11.80	14.75	17.70	20.65	23.60	26.54	29.49	35.39	41.29	47.19
	Area	4.875	7.313	9.750	12.19	14.63	17.06	19.50	21.94	24.38	29.25	34.13	39.00
	I x-x	617.9	926.9	1236.	1545.	1854.	2163.	2472.	2781.	3090.	3707.	4325.	4943.
	I y-y	0.006	0.021	0.051	0.099	0.171	0.272	0.406	0.578	0.793	1.371	2.177	3.250
39½	Wt.	5.974	8.962	11.95	14.94	17.92	20.91	23.90	26.88	29.87	35.85	41.82	47.80
	Area	4.938	7.406	9.875	12.34	14.81	17.28	19.75	22.22	24.69	29.63	34.56	39.50
	I x-x	642.0	963.0	1284.	1605.	1926.	2247.	2568.	2889.	3210.	3852.	4494.	5136.
	I y-y	0.006	0.022	0.051	0.100	0.174	0.276	0.411	0.586	0.804	1.389	2.205	3.292



RECTANGLES

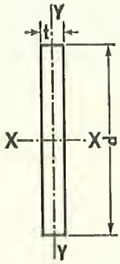
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
40	Wt.	6.050	9.075	12.10	15.13	18.15	21.18	24.20	27.23	30.25	36.30	42.35	48.40
	Area	5.000	7.500	10.00	12.50	15.00	17.50	20.00	22.50	25.00	30.00	35.00	40.00
	I x-x	666.7	1000.	1333.	1667.	2000.	2333.	2667.	3000.	3333.	4000.	4667.	5333.
	I y-y	0.007	0.022	0.052	0.102	0.176	0.279	0.417	0.593	0.814	1.406	2.233	3.333
40½	Wt.	6.126	9.189	12.25	15.31	18.38	21.44	24.50	27.57	30.63	36.75	42.88	49.01
	Area	5.063	7.594	10.13	12.66	15.19	17.72	20.25	22.78	25.31	30.38	35.44	40.50
	I x-x	692.0	1038.	1384.	1730.	2076.	2422.	2768.	3114.	3460.	4152.	4844.	5536.
	I y-y	0.007	0.022	0.053	0.103	0.178	0.283	0.422	0.601	0.824	1.424	2.261	3.375
41	Wt.	6.201	9.302	12.40	15.50	18.60	21.70	24.81	27.91	31.01	37.21	43.41	49.61
	Area	5.125	7.688	10.25	12.81	15.38	17.94	20.50	23.06	25.63	30.75	35.88	41.00
	I x-x	717.9	1077.	1436.	1795.	2154.	2513.	2872.	3231.	3590.	4308.	5026.	5743.
	I y-y	0.007	0.023	0.053	0.104	0.180	0.286	0.427	0.608	0.834	1.441	2.289	3.417
41½	Wt.	6.277	9.416	12.55	15.69	18.83	21.97	25.11	28.25	31.38	37.66	43.94	50.22
	Area	5.188	7.781	10.38	12.97	15.56	18.16	20.75	23.34	25.94	31.13	36.31	41.50
	I x-x	744.5	1117.	1489.	1861.	2234.	2606.	2978.	3350.	3723.	4467.	5212.	5956.
	I y-y	0.007	0.023	0.054	0.106	0.182	0.290	0.432	0.616	0.844	1.459	2.317	3.458
42	Wt.	6.353	9.529	12.71	15.88	19.06	22.23	25.41	28.59	31.76	38.12	44.47	50.82
	Area	5.250	7.875	10.50	13.13	15.75	18.38	21.00	23.63	26.25	31.50	36.75	42.00
	I x-x	771.8	1158.	1544.	1929.	2315.	2701.	3087.	3473.	3859.	4631.	5402.	6174.
	I y-y	0.007	0.023	0.055	0.107	0.185	0.293	0.438	0.623	0.854	1.477	2.345	3.500
42½	Wt.	6.428	9.642	12.86	16.07	19.28	22.50	25.71	28.93	32.14	38.57	45.00	51.43
	Area	5.313	7.969	10.63	13.28	15.94	18.59	21.25	23.91	26.56	31.88	37.19	42.50
	I x-x	799.6	1199.	1599.	1999.	2399.	2799.	3199.	3598.	3998.	4798.	5598.	6397.
	I y-y	0.007	0.023	0.055	0.108	0.187	0.297	0.443	0.630	0.865	1.494	2.373	3.542
43	Wt.	6.504	9.756	13.01	16.26	19.51	22.76	26.02	29.27	32.52	39.02	45.53	52.03
	Area	5.375	8.063	10.75	13.44	16.13	18.81	21.50	24.19	26.88	32.25	37.63	43.00
	I x-x	828.2	1242.	1656.	2070.	2485.	2899.	3313.	3727.	4141.	4969.	5797.	6626.
	I y-y	0.007	0.024	0.056	0.109	0.189	0.300	0.448	0.638	0.875	1.512	2.401	3.583
43½	Wt.	6.579	9.869	13.16	16.45	19.74	23.03	26.32	29.61	32.90	39.48	46.06	52.64
	Area	5.438	8.156	10.88	13.59	16.31	19.03	21.75	24.47	27.19	32.63	38.06	43.50
	I x-x	857.4	1286.	1715.	2144.	2572.	3001.	3430.	3858.	4287.	5145.	6002.	6859.
	I y-y	0.007	0.024	0.057	0.111	0.191	0.304	0.453	0.645	0.885	1.529	2.428	3.625



RECTANGLES

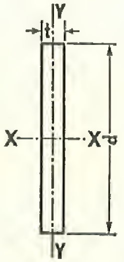
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
44	Wt.	6.655	9.983	13.31	16.64	19.97	23.29	26.62	29.95	33.28	39.93	46.59	53.24
	Area	5.500	8.250	11.00	13.75	16.50	19.25	22.00	24.75	27.50	33.00	38.50	44.00
	I x-x	887.3	1331.	1775.	2218.	2662.	3106.	3549.	3993.	4437.	5324.	6211.	7099.
	I y-y	0.007	0.024	0.057	0.112	0.193	0.307	0.458	0.653	0.895	1.547	2.456	3.667
44½	Wt.	6.731	10.10	13.46	16.83	20.19	23.56	26.92	30.29	33.65	40.38	47.11	53.85
	Area	5.563	8.344	11.13	13.91	16.69	19.47	22.25	25.03	27.81	33.38	38.94	44.50
	I x-x	917.9	1377.	1836.	2295.	2754.	3213.	3672.	4131.	4590.	5508.	6426.	7343.
	I y-y	0.007	0.024	0.058	0.113	0.196	0.311	0.464	0.660	0.905	1.564	2.484	3.708
45	Wt.	6.806	10.21	13.61	17.02	20.42	23.82	27.23	30.63	34.03	40.84	47.64	54.45
	Area	5.625	8.438	11.25	14.06	16.88	19.69	22.50	25.31	28.13	33.75	39.38	45.00
	I x-x	949.2	1424.	1898.	2373.	2848.	3322.	3797.	4271.	4746.	5695.	6645.	7594.
	I y-y	0.007	0.025	0.059	0.114	0.198	0.314	0.469	0.667	0.916	1.582	2.512	3.750
45½	Wt.	6.882	10.32	13.76	17.20	20.65	24.09	27.53	30.97	34.41	41.29	48.17	55.06
	Area	5.688	8.531	11.38	14.22	17.06	19.91	22.75	25.59	28.44	34.13	39.81	45.50
	I x-x	981.2	1472.	1962.	2453.	2944.	3434.	3925.	4415.	4906.	5887.	6868.	7850.
	I y-y	0.007	0.025	0.059	0.116	0.200	0.318	0.474	0.675	0.926	1.600	2.540	3.792
46	Wt.	6.958	10.44	13.92	17.39	20.87	24.35	27.83	31.31	34.79	41.75	48.70	55.66
	Area	5.750	8.625	11.50	14.38	17.25	20.13	23.00	25.88	28.75	34.50	40.25	46.00
	I x-x	1014.	1521.	2028.	2535.	3042.	3549.	4056.	4563.	5070.	6084.	7097.	8111.
	I y-y	0.007	0.025	0.060	0.117	0.202	0.321	0.479	0.682	0.936	1.617	2.568	3.833
46½	Wt.	7.033	10.55	14.07	17.58	21.10	24.62	28.13	31.65	35.17	42.20	49.23	56.27
	Area	5.813	8.719	11.63	14.53	17.44	20.34	23.25	26.16	29.06	34.88	40.69	46.50
	I x-x	1047.	1571.	2095.	2618.	3142.	3666.	4189.	4713.	5237.	6284.	7331.	8379.
	I y-y	0.008	0.026	0.061	0.118	0.204	0.324	0.484	0.690	0.946	1.635	2.596	3.875
47	Wt.	7.109	10.66	14.22	17.77	21.33	24.88	28.44	31.99	35.54	42.65	49.76	56.87
	Area	5.875	8.813	11.75	14.69	17.63	20.56	23.50	26.44	29.38	35.25	41.13	47.00
	I x-x	1081.	1622.	2163.	2704.	3244.	3785.	4326.	4867.	5407.	6489.	7570.	8652.
	I y-y	0.008	0.026	0.061	0.120	0.207	0.328	0.490	0.697	0.956	1.652	2.624	3.917
48	Wt.	7.260	10.89	14.52	18.15	21.78	25.41	29.04	32.67	36.30	43.56	50.82	58.08
	Area	6.000	9.000	12.00	15.00	18.00	21.00	24.00	27.00	30.00	36.00	42.00	48.00
	I x-x	1152.	1728.	2304.	2880.	3456.	4032.	4608.	5184.	5760.	6912.	8064.	9216.
	I y-y	0.008	0.026	0.063	0.122	0.211	0.335	0.500	0.712	0.977	1.687	2.680	4.000



RECTANGLES

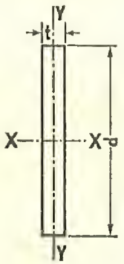
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\frac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\frac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289\ d$; $r_{y\text{-}y}=0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
49	Wt.	7.411	11.12	14.82	18.53	22.23	25.94	29.65	33.35	37.06	44.47	51.88	59.29
	Area	6.125	9.188	12.25	15.31	18.38	21.44	24.50	27.56	30.63	36.75	42.88	49.00
	I x-x	1226.	1838.	2451.	3064.	3677.	4289.	4902.	5515.	6128.	7353.	8579.	9804.
	I y-y	0.008	0.027	0.064	0.125	0.215	0.342	0.510	0.727	0.997	1.723	2.736	4.083
50	Wt.	7.563	11.34	15.13	18.91	22.69	26.47	30.25	34.03	37.81	45.38	52.94	60.50
	Area	6.250	9.375	12.50	15.63	18.75	21.88	25.00	28.13	31.25	37.50	43.75	50.00
	I x-x	1302.	1953.	2604.	3255.	3906.	4557.	5208.	5859.	6510.	7813.	9115.	10417
	I y-y	0.008	0.027	0.065	0.127	0.220	0.349	0.521	0.742	1.017	1.758	2.791	4.167
51	Wt.	7.714	11.57	15.43	19.28	23.14	27.00	30.86	34.71	38.57	46.28	54.00	61.71
	Area	6.375	9.563	12.75	15.94	19.13	22.31	25.50	28.69	31.88	38.25	44.63	51.00
	I x-x	1382.	2073.	2764.	3454.	4145.	4836.	5527.	6218.	6909.	8291.	9672.	11054
	I y-y	0.008	0.028	0.066	0.130	0.224	0.356	0.531	0.756	1.038	1.793	2.847	4.250
52	Wt.	7.865	11.80	15.73	19.66	23.60	27.53	31.46	35.39	39.33	47.19	55.06	62.92
	Area	6.500	9.750	13.00	16.25	19.50	22.75	26.00	29.25	32.50	39.00	45.50	52.00
	I x-x	1465.	2197.	2929.	3662.	4394.	5126.	5859.	6591.	7323.	8788.	10253	11717
	I y-y	0.008	0.029	0.068	0.132	0.229	0.363	0.542	0.771	1.058	1.828	2.903	4.333
53	Wt.	8.016	12.02	16.03	20.04	24.05	28.06	32.07	36.07	40.08	48.10	56.11	64.13
	Area	6.625	9.938	13.25	16.56	19.88	23.19	26.50	29.81	33.13	39.75	46.38	53.00
	I x-x	1551.	2326.	3102.	3877.	4652.	5428.	6203.	6979.	7754.	9305.	10856	12406
	I y-y	0.009	0.029	0.069	0.135	0.233	0.370	0.552	0.786	1.078	1.863	2.959	4.417
54	Wt.	8.168	12.25	16.34	20.42	24.50	28.59	32.67	36.75	40.84	49.01	57.17	65.34
	Area	6.750	10.13	13.50	16.88	20.25	23.63	27.00	30.38	33.75	40.50	47.25	54.00
	I x-x	1640.	2460.	3281.	4101.	4921.	5741.	6561.	7381.	8201.	9842.	11482	13122
	I y-y	0.009	0.030	0.070	0.137	0.237	0.377	0.563	0.801	1.099	1.898	3.015	4.500
55	Wt.	8.319	12.48	16.64	20.80	24.96	29.12	33.28	37.43	41.59	49.91	58.23	66.55
	Area	6.875	10.31	13.75	17.19	20.63	24.06	27.50	30.94	34.38	41.25	48.13	55.00
	I x-x	1733.	2600.	3466.	4333.	5199.	6066.	6932.	7799.	8665.	10398	12132	13865
	I y-y	0.009	0.030	0.072	0.140	0.242	0.384	0.573	0.816	1.119	1.934	3.070	4.583
56	Wt.	8.470	12.71	16.94	21.18	25.41	29.65	33.88	38.12	42.35	50.82	59.29	67.76
	Area	7.000	10.50	14.00	17.50	21.00	24.50	28.00	31.50	35.00	42.00	49.00	56.00
	I x-x	1829.	2744.	3659.	4573.	5488.	6403.	7317.	8232.	9147.	10976	12805	14635
	I y-y	0.009	0.031	0.073	0.142	0.246	0.391	0.583	0.831	1.139	1.969	3.126	4.667



RECTANGLES

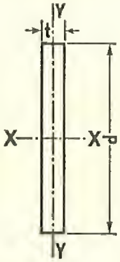
ELEMENTS OF SECTIONS

All dimensions in inches. Area in square inches.
Weight in pounds per foot. I = Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x} = \dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y} = \dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x} = 0.289\ d$; $r_{y\text{-}y} = 0.289\ t$

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
57	Wt.	8.621	12.93	17.24	21.55	25.86	30.17	34.49	38.80	43.11	51.73	60.35	68.97
	Area	7.125	10.69	14.25	17.81	21.38	24.94	28.50	32.06	35.63	42.75	49.88	57.00
	I x-x	1929.	2894.	3858.	4823.	5787.	6752.	7716.	8681.	9645.	11575	13504	15433
	I y-y	0.009	0.031	0.074	0.145	0.250	0.398	0.594	0.845	1.160	2.004	3.182	4.750
58	Wt.	8.773	13.16	17.55	21.93	26.32	30.70	35.09	39.48	43.86	52.64	61.41	70.18
	Area	7.250	10.88	14.50	18.13	21.75	25.38	29.00	32.63	36.25	43.50	50.75	58.00
	I x-x	2032.	3049.	4065.	5081.	6097.	7113.	8130.	9146.	10162	12195	14227	16259
	I y-y	0.009	0.032	0.076	0.148	0.255	0.405	0.604	0.860	1.180	2.039	3.238	4.833
59	Wt.	8.924	13.39	17.85	22.31	26.77	31.23	35.70	40.16	44.62	53.54	62.47	71.39
	Area	7.375	11.06	14.75	18.44	22.13	25.81	29.50	33.19	36.88	44.25	51.63	59.00
	I x-x	2139.	3209.	4279.	5348.	6418.	7488.	8557.	9627.	10697	12836	14976	17115
	I y-y	0.010	0.032	0.077	0.150	0.259	0.412	0.615	0.875	1.200	2.074	3.294	4.917
60	Wt.	9.075	13.61	18.15	22.69	27.23	31.76	36.30	40.84	45.38	54.45	63.53	72.60
	Area	7.500	11.25	15.00	18.75	22.50	26.25	30.00	33.75	37.50	45.00	52.50	60.00
	I x-x	2250.	3375.	4500.	5625.	6750.	7875.	9000.	10125	11250	13500	15750	18000
	I y-y	0.010	0.033	0.078	0.153	0.264	0.419	0.625	0.890	1.221	2.109	3.350	5.000
61	Wt.	9.226	13.84	18.45	23.07	27.68	32.29	36.91	41.52	46.13	55.36	64.58	73.81
	Area	7.625	11.44	15.25	19.06	22.88	26.69	30.50	34.31	38.13	45.75	53.38	61.00
	I x-x	2364.	3547.	4729.	5911.	7093.	8275.	9458.	10640	11822	14186	16551	18915
	I y-y	0.010	0.034	0.079	0.155	0.268	0.426	0.635	0.905	1.241	2.145	3.405	5.083
62	Wt.	9.378	14.07	18.76	23.44	28.13	32.82	37.51	42.20	46.89	56.27	65.64	75.02
	Area	7.750	11.63	15.50	19.38	23.25	27.13	31.00	34.88	38.75	46.50	54.25	62.00
	I x-x	2483.	3724.	4965.	6206.	7448.	8689.	9930.	11172	12413	14896	17378	19861
	I y-y	0.010	0.034	0.081	0.158	0.272	0.433	0.646	0.920	1.261	2.180	3.461	5.167
63	Wt.	9.529	14.29	19.06	23.82	28.59	33.35	38.12	42.88	47.64	57.17	66.70	76.23
	Area	7.875	11.81	15.75	19.69	23.63	27.56	31.50	35.44	39.38	47.25	55.13	63.00
	I x-x	2605.	3907.	5209.	6512.	7814.	9116.	10419	11721	13023	15628	18233	20837
	I y-y	0.010	0.035	0.082	0.160	0.277	0.440	0.656	0.934	1.282	2.215	3.517	5.250
64	Wt.	9.680	14.52	19.36	24.20	29.04	33.88	38.72	43.56	48.40	58.08	67.76	77.44
	Area	8.000	12.00	16.00	20.00	24.00	28.00	32.00	36.00	40.00	48.00	56.00	64.00
	I x-x	2731.	4096.	5461.	6827.	8192.	9557.	10923	12288	13653	16384	19115	21845
	I y-y	0.010	0.035	0.083	0.163	0.281	0.447	0.667	0.949	1.302	2.250	3.573	5.333



RECTANGLES

ELEMENTS OF SECTIONS

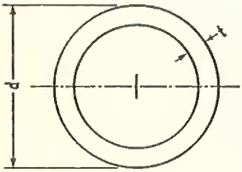
All dimensions in inches. Area in square inches.
Weight in pounds per foot. I=Moment of Inertia in in.^{4}

Section Modulus: $S_{x\text{-}x}=\dfrac{I_{x\text{-}x}}{d/2}$; $S_{y\text{-}y}=\dfrac{I_{y\text{-}y}}{t/2}$

Radius of Gyration: $r_{x\text{-}x}=0.289$ d; $r_{y\text{-}y}=0.289$ t

Depth, d		Thickness, t											
		1/8	3/16	1/4	5/16	3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
65	Wt.	9.831	14.75	19.66	24.58	29.49	34.41	39.33	44.24	49.16	58.99	68.82	78.65
	Area	8.125	12.19	16.25	20.31	24.38	28.44	32.50	36.56	40.63	48.75	56.88	65.00
	I x-x	2861.	4291.	5721.	7152.	8582.	10012	11443	12873	14303	17164	20025	22885
	I y-y	0.011	0.036	0.085	0.165	0.286	0.454	0.677	0.964	1.322	2.285	3.629	5.417
66	Wt.	9.983	14.97	19.97	24.96	29.95	34.94	39.93	44.92	49.91	59.90	69.88	79.86
	Area	8.250	12.38	16.50	20.63	24.75	28.88	33.00	37.13	41.25	49.50	57.75	66.00
	I x-x	2995.	4492.	5990.	7487.	8948.	10482	11979	13476	14974	17969	20963	23958
	I y-y	0.011	0.036	0.086	0.168	0.290	0.461	0.688	0.979	1.343	2.320	3.685	5.500
67	Wt.	10.13	15.20	20.27	25.33	30.40	35.47	40.54	45.60	50.67	60.80	70.94	81.07
	Area	8.375	12.56	16.75	20.94	25.13	29.31	33.50	37.69	41.88	50.25	58.63	67.00
	I x-x	3133.	4699.	6266.	7832.	9399.	10965	12532	14098	15665	18798	21931	25064
	I y-y	0.011	0.037	0.087	0.170	0.294	0.468	0.698	0.994	1.363	2.355	3.740	5.583
68	Wt.	10.29	15.43	20.57	25.71	30.86	36.00	41.14	46.28	51.43	61.71	72.00	82.28
	Area	8.500	12.75	17.00	21.25	25.50	29.75	34.00	38.25	42.50	51.00	59.50	68.00
	I x-x	3275.	4913.	6551.	8188.	9826.	11464	13101	14739	16377	19652	22927	26203
	I y-y	0.011	0.037	0.089	0.173	0.299	0.475	0.708	1.009	1.383	2.391	3.796	5.667
69	Wt.	10.44	15.65	20.87	26.09	31.31	36.53	41.75	46.96	52.18	62.62	73.05	83.49
	Area	8.625	12.94	17.25	21.56	25.88	30.19	34.50	38.81	43.13	51.75	60.38	69.00
	I x-x	3422.	5133.	6844.	8555.	10266	11977	13688	15399	17110	20532	23954	27376
	I y-y	0.011	0.038	0.090	0.175	0.303	0.482	0.719	1.023	1.404	2.426	3.852	5.750
70	Wt.	10.59	15.88	21.18	26.47	31.76	37.06	42.35	47.64	52.94	63.53	74.11	84.70
	Area	8.750	13.13	17.50	21.88	26.25	30.63	35.00	39.38	43.75	52.50	61.25	70.00
	I x-x	3573.	5359.	7146.	8932.	10719	12505	14292	16078	17865	21438	25010	28583
	I y-y	0.011	0.038	0.091	0.178	0.308	0.488	0.729	1.038	1.424	2.461	3.908	5.833
71	Wt.	10.74	16.11	21.48	26.85	32.22	37.59	42.96	48.32	53.69	64.43	75.17	85.91
	Area	8.875	13.31	17.75	22.19	26.63	31.06	35.50	39.94	44.38	53.25	62.13	71.00
	I x-x	3728.	5592.	7456.	9321.	11185	13049	14913	16777	18641	22369	26098	29826
	I y-y	0.012	0.039	0.092	0.181	0.312	0.495	0.740	1.053	1.444	2.496	3.964	5.917
72	Wt.	10.89	16.34	21.78	27.23	32.67	38.12	43.56	49.01	54.45	65.34	76.23	87.12
	Area	9.000	13.50	18.00	22.50	27.00	31.50	36.00	40.50	45.00	54.00	63.00	72.00
	I x-x	3888.	5832.	7776.	9720.	11664	13608	15552	17496	19440	23328	27216	31104
	I y-y	0.012	0.040	0.094	0.183	0.316	0.502	0.750	1.068	1.465	2.531	4.020	6.000

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

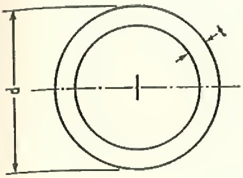
Diameter, d	½					¾				
Thickness, t	1/32	1/16	3/32	1/8	5/32	1/32	1/16	3/32	1/8	3/16
Weight	0.056	0.104	0.145	0.178	0.204	0.085	0.163	0.234	0.297	0.401
Area	0.046	0.086	0.120	0.147	0.169	0.071	0.135	0.193	0.245	0.331
I	0.001	0.002	0.003	0.003	0.003	0.005	0.008	0.011	0.012	0.015
S	0.005	0.008	0.010	0.012	0.012	0.012	0.021	0.028	0.033	0.039
r	0.166	0.156	0.147	0.140	0.134	0.254	0.244	0.234	0.225	0.210

Diameter, d	1					1¼				
Thickness, t	1/32	1/16	1/8	3/16	1/4	1/32	1/16	1/8	3/16	1/4
Weight	0.115	0.223	0.416	0.579	0.713	0.145	0.282	0.535	0.757	0.950
Area	0.095	0.184	0.344	0.479	0.589	0.120	0.233	0.442	0.626	0.785
I	0.011	0.020	0.034	0.042	0.046	0.022	0.041	0.071	0.091	0.104
S	0.022	0.041	0.067	0.083	0.092	0.036	0.066	0.113	0.146	0.167
r	0.342	0.332	0.313	0.295	0.280	0.431	0.420	0.400	0.381	0.364

Diameter, d	1½					1¾				
Thickness, t	1/32	1/16	1/8	3/16	1/4	1/32	1/16	1/8	3/16	1/4
Weight	0.175	0.342	0.653	0.936	1.188	0.204	0.401	0.772	1.114	1.426
Area	0.144	0.282	0.540	0.773	0.982	0.169	0.331	0.638	0.920	1.178
I	0.039	0.073	0.129	0.170	0.199	0.062	0.118	0.212	0.285	0.341
S	0.052	0.097	0.172	0.227	0.266	0.071	0.135	0.242	0.326	0.389
r	0.519	0.509	0.488	0.469	0.451	0.608	0.597	0.576	0.556	0.538

Diameter, d	2					2¼				
Thickness, t	1/16	1/8	3/16	1/4	5/16	1/16	1/8	3/16	1/4	5/16
Weight	0.460	0.891	1.292	1.663	2.005	0.520	1.010	1.470	1.901	2.302
Area	0.380	0.736	1.068	1.374	1.657	0.430	0.834	1.215	1.571	1.902
I	0.179	0.325	0.443	0.537	0.610	0.257	0.473	0.651	0.798	0.916
S	0.179	0.325	0.443	0.537	0.610	0.229	0.420	0.579	0.709	0.814
r	0.685	0.664	0.644	0.625	0.607	0.774	0.753	0.732	0.713	0.694

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I = Moment of Inertia in in.^{4}
S = Section Modulus in in.^{3}
r = Radius of Gyration in inches.

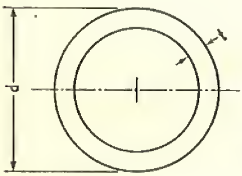
Diameter, d	2½					2¾				
Thickness, t	1/16	1/8	3/16	1/4	5/16	1/16	1/8	3/16	1/4	5/16
Weight	0.579	1.129	1.648	2.138	2.599	0.639	1.247	1.827	2.376	2.896
Area	0.479	0.933	1.362	1.767	2.148	0.528	1.031	1.510	1.964	2.393
I	0.356	0.660	0.917	1.132	1.311	0.477	0.890	1.246	1.549	1.807
S	0.285	0.528	0.733	0.906	1.049	0.347	0.647	0.906	1.127	1.314
r	0.862	0.841	0.820	0.800	0.781	0.950	0.929	0.908	0.888	0.869

Diameter, d	3					3¼				
Thickness, t	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	5/16	3/8
Weight	1.366	2.005	2.614	3.193	3.742	1.485	2.183	2.851	3.490	4.098
Area	1.129	1.657	2.160	2.639	3.093	1.227	1.804	2.356	2.884	3.387
I	1.169	1.646	2.059	2.414	2.718	1.501	2.123	2.669	3.146	3.559
S	0.779	1.097	1.373	1.610	1.812	0.923	1.306	1.643	1.936	2.190
r	1.017	0.997	0.976	0.957	0.938	1.106	1.085	1.064	1.044	1.025

Diameter, d	3½					3¾				
Thickness, t	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	5/16	3/8
Weight	1.604	2.361	3.089	3.787	4.455	1.722	2.539	3.326	4.084	4.811
Area	1.325	1.951	2.553	3.129	3.682	1.424	2.099	2.749	3.375	3.976
I	1.890	2.685	3.390	4.013	4.559	2.341	3.339	4.231	5.026	5.732
S	1.080	1.534	1.937	2.293	2.605	1.249	1.781	2.256	2.681	3.057
r	1.194	1.173	1.153	1.132	1.113	1.282	1.261	1.241	1.220	1.201

Diameter, d	4					4¼				
Thickness, t	1/8	3/16	1/4	5/16	3/8	1/8	3/16	1/4	5/16	3/8
Weight	1.841	2.717	3.564	4.380	5.167	1.960	2.896	3.801	4.678	5.524
Area	1.522	2.246	2.945	3.620	4.271	1.620	2.393	3.142	3.866	4.565
I	2.859	4.090	5.200	6.198	7.090	3.449	4.948	6.308	7.539	8.649
S	1.429	2.045	2.600	3.098	3.544	1.623	2.328	2.968	3.548	4.070
r	1.371	1.350	1.329	1.308	1.289	1.459	1.438	1.417	1.397	1.376

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.

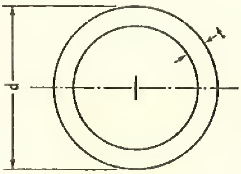
Diameter, d	4½					4¾				
Thickness, t	⅛	3/16	¼	5/16	⅜	⅛	3/16	¼	5/16	⅜
Weight	2.079	3.074	4.039	4.974	5.880	2.198	3.252	4.277	5.271	6.237
Area	1.718	2.540	3.338	4.111	4.860	1.816	2.688	3.534	4.357	5.154
I	4.114	5.917	7.563	9.062	10.42	4.860	7.006	8.975	10.78	12.42
S	1.829	2.630	3.362	4.028	4.633	2.047	2.950	3.779	4.538	5.231
r	1.547	1.526	1.505	1.485	1.464	1.636	1.615	1.594	1.573	1.553

Diameter, d	5					5¼				
Thickness, t	3/16	¼	5/16	⅜	7/16	3/16	¼	5/16	⅜	7/16
Weight	3.430	4.514	5.568	6.593	7.588	3.608	4.752	5.865	6.949	8.004
Area	2.835	3.731	4.602	5.449	6.271	2.982	3.927	4.847	5.743	6.615
I	8.220	10.55	12.70	14.67	16.47	9.568	12.30	14.83	17.16	19.31
S	3.288	4.220	5.078	5.866	6.587	3.645	4.687	5.650	6.538	7.356
r	1.703	1.682	1.661	1.641	1.621	1.791	1.770	1.749	1.729	1.709

Diameter, d	5½					6				
Thickness, t	3/16	¼	5/16	⅜	7/16	3/16	¼	5/16	⅜	½
Weight	3.787	4.989	6.162	7.306	8.419	4.143	5.465	6.756	8.018	10.45
Area	3.129	4.123	5.093	6.038	6.958	3.424	4.516	5.584	6.627	8.639
I	11.05	14.24	17.19	19.93	22.46	14.47	18.70	22.65	26.33	32.94
S	4.020	5.178	6.252	7.247	8.166	4.825	6.232	7.547	8.774	10.98
r	1.879	1.858	1.837	1.817	1.797	2.056	2.035	2.014	1.993	1.953

Diameter, d	6½					7				
Thickness, t	3/16	¼	5/16	⅜	½	3/16	¼	5/16	⅜	½
Weight	4.499	5.940	7.350	8.731	11.40	4.856	6.415	7.944	9.444	12.35
Area	3.718	4.909	6.075	7.216	9.425	4.013	5.302	6.566	7.805	10.21
I	18.54	24.01	29.15	33.97	42.71	23.30	30.23	36.78	42.96	54.24
S	5.703	7.385	8.966	10.45	13.14	6.656	8.638	10.51	12.27	15.50
r	2.233	2.212	2.190	2.170	2.129	2.410	2.388	2.367	2.346	2.305

ROUND TUBING



ELEMENTS OF SECTIONS

All dimensions in inches.
Weight in pounds per foot.
Area in square inches.

I=Moment of Inertia in in.^{4}
S=Section Modulus in in.^{3}
r=Radius of Gyration in inches.

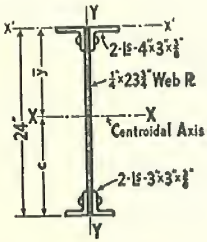
Diameter, d	7½					8				
Thickness, t	3/16	¼	5/16	⅜	½	3/16	¼	5/16	⅜	½
Weight	5.212	6.890	8.538	10.16	13.31	5.568	7.365	9.132	10.87	14.26
Area	4.307	5.694	7.056	8.394	11.00	4.602	6.087	7.547	8.983	11.78
I	28.81	37.46	45.66	53.42	67.70	35.13	45.75	55.84	65.45	83.21
S	7.683	9.989	12.18	14.24	18.05	8.780	11.43	13.96	16.36	20.80
r	2.586	2.565	2.544	2.523	2.481	2.763	2.742	2.720	2.699	2.658

Diameter, d	8½					9				
Thickness, t	3/16	¼	5/16	⅜	½	3/16	¼	5/16	⅜	½
Weight	5.924	7.840	9.726	11.58	15.21	6.281	8.316	10.32	12.29	16.16
Area	4.896	6.480	8.038	9.572	12.57	5.191	6.872	8.529	10.16	13.35
I	42.32	55.18	67.45	79.16	100.9	50.42	65.82	80.57	94.67	121.0
S	9.956	12.98	15.87	18.63	23.75	11.20	14.63	17.91	21.04	26.89
r	2.940	2.918	2.897	2.876	2.834	3.116	3.095	3.074	3.052	3.010

Diameter, d	9½					10				
Thickness, t	3/16	¼	5/16	⅜	½	3/16	¼	5/16	⅜	½
Weight	6.637	8.791	10.91	13.01	17.11	6.994	9.266	11.51	13.72	18.06
Area	5.485	7.265	9.020	10.75	14.14	5.780	7.658	9.510	11.34	14.92
I	59.49	77.76	95.28	112.1	143.6	69.59	91.06	111.7	131.5	168.8
S	12.52	16.36	20.05	23.59	30.22	13.92	18.21	22.34	26.30	33.76
r	3.293	3.272	3.250	3.229	3.187	3.470	3.448	3.427	3.406	3.363

Diameter, d	10½					11				
Thickness, t	3/16	¼	5/16	⅜	½	3/16	¼	5/16	⅜	½
Weight	7.350	9.741	12.10	14.43	19.01	7.706	10.22	12.70	15.14	19.96
Area	6.074	8.050	10.00	11.93	15.71	6.369	8.443	10.49	12.52	16.49
I	80.78	105.8	129.9	153.1	196.8	93.10	122.0	149.9	176.9	227.8
S	15.39	20.15	24.74	29.15	37.49	16.93	22.19	27.26	32.16	41.42
r	3.647	3.625	3.604	3.582	3.540	3.823	3.802	3.780	3.759	3.717

PLATE GIRDER



ELEMENTS OF SECTION

These are typical calculations for the various elements of a section of a plate girder. They include not only the ordinary values: area, moment of inertia, and section modulus, but also torsional moment of inertia, J, and moment of inertia of compression flange, I_F. The latter values are needed for determining critical buckling stress of compression flange, see page 48.

Section	Weight	Area (gross)	About axis X'-X'				About axis Y-Y			J[1]
			y	Ay	Ay^2	I_o	x	Ax^2	I_o	
2 ∠ 4"×3"×3/8"....	6.02	4.98	0.77	3.8	3	4	1.39	9.6	7.8	0.246
1PL 1/4"×23 3/4"....	7.18	5.94	12.00	71.3	855	279	0.00	0.0	0.0	0.124
2 ∠ 3"×3"×3/8"....	5.10	4.20	23.13	97.1	2247	3	1.00	4.2	3.4	0.210
	18.30	15.12		172.2	3105	286		13.8	11.2	0.580

[1]Torsion factor. Values for angles taken from pages 93 and 94. Values for plate obtained according to formula on page 49: $\frac{1}{3} \times 23.75 \times \overline{0.25}^3 = 0.124$

Weight = 18.30 lb./ft.

Area = 15.12 sq. in.

$$\bar{y} = \frac{172.2}{15.12} = 11.4 \text{ inches}$$

$$c = 24 - 11.4 = 12.6 \text{ inches}$$

$$I_X = 3105 + 286 - 172.2 \times 11.4 = 1430 \text{ in.}^4$$

$$I_Y = 13.8 + 11.2 = 25.0 \text{ in.}^4$$

$$S \text{ (top flange)} = \frac{1430}{11.4} = 125 \text{ in.}^3$$

$$S \text{ (bottom flange)} = \frac{1430}{12.6} = 114 \text{ in.}^3 \text{ (See note.)}$$

$$J = 0.580 \text{ in.}^4$$

I_F (moment of inertia of compression flange about axis Y) $= 9.6 + 7.8 = 17.4$ in.^{4}

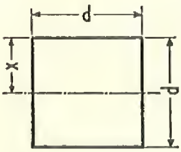
Note.—These section elements are based on gross area and therefore the section modulus values divided into any given bending moment give extreme fiber stresses based on gross area. To obtain the stresses based on net area, multiply gross stress by ratio of gross to net area. Thus the bottom flange stress in this girder, based on net area, assuming 21/32 in. rivet holes, is:

$$\frac{M}{114} \times \frac{4.20}{4.20 - 0.49} = \frac{M}{114} \times 1.13$$

FORMULAS

TABLE 22—FORMULAS FOR ELEMENTS OF SECTIONS

Figure 1



$A = d^2$

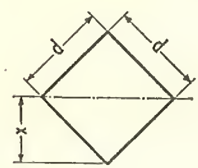
$x = \frac{d}{2}$

$I = \frac{d^4}{12}$

$S = \frac{d^3}{6}$

$r = \frac{d}{\sqrt{12}} = 0.2887d$

Figure 2



$A = d^2$

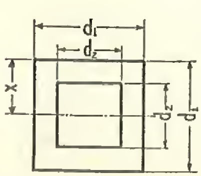
$x = \frac{d}{\sqrt{2}} = 0.7071d$

$I = \frac{d^4}{12}$

$S = \frac{\sqrt{2}\, d^3}{12} = 0.1179d^3$

$r = \frac{d}{\sqrt{12}} = 0.2887d$

Figure 3



$A = d_1^2 - d_2^2$

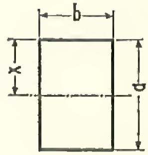
$x = \frac{d_1}{2}$

$I = \frac{d_1^4 - d_2^4}{12}$

$S = \frac{d_1^4 - d_2^4}{6d_1}$

$r = \sqrt{\frac{d_1^2 + d_2^2}{12}}$

Figure 4



$A = bd$

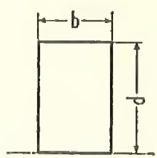
$x = \frac{d}{2}$

$I = \frac{bd^3}{12}$

$S = \frac{bd^2}{6}$

$r = \frac{d}{\sqrt{12}} = 0.2887d$

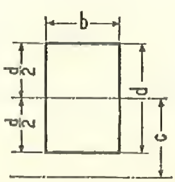
Figure 5



$A = bd$

$I = \frac{bd^3}{3}$

Figure 6

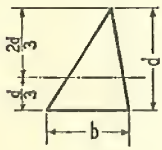


$A = bd$

$I = A\left(\frac{d^2}{12} + c^2\right)$

TABLE 22—FORMULAS FOR ELEMENTS OF SECTIONS—Continued

Figure 7



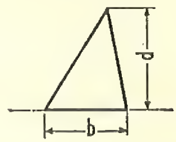
$$A=\frac{bd}{2}$$

$$I=\frac{bd^3}{36}$$

$$S=\frac{bd^2}{24}$$

$$r=\frac{d}{\sqrt{18}}=0.2357d$$

Figure 8

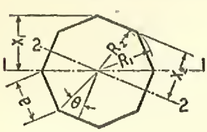


$$A=\frac{bd}{2}$$

$$I=\frac{bd^3}{12}$$

Figure 9

Regular Polygon



n = Number of Sides

$$a=2\sqrt{R_1^2-R_2^2}\ ,\Theta=\frac{180^\circ}{n}$$

$$A=\frac{na^2\cot\Theta}{4}=\frac{nR_1^2\sin 2\Theta}{2}=nR_2^2\tan\Theta$$

$$x_1=R_1=\frac{a}{2\sin\Theta},\quad x_2=R_2=\frac{a}{2\tan\Theta}$$

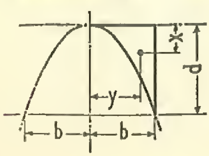
$$I_{1\text{-}1}=I_{2\text{-}2}=\frac{A\ (6R_1^2-a^2)}{24}=\frac{A\ (12R_2^2+a^2)}{48}$$

$$S_{1\text{-}1}=\frac{A\ (6R_1^2-a^2)}{24R_1},\quad S_{2\text{-}2}=\frac{A\ (12R_2^2+a^2)}{48R_2}$$

$$r_{1\text{-}1}=\sqrt{\frac{6R_1^2-a^2}{24}},\quad r_{2\text{-}2}=\sqrt{\frac{12R_2^2+a^2}{48}}$$

Figure 10

Parabola: $y=-ax^2$



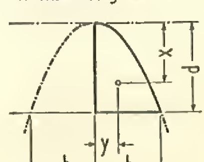
$$A=\frac{bd}{3}$$

$$x=\frac{3d}{10}$$

$$y=\frac{3b}{4}$$

Figure 11

Parabola: $y=-ax^2$



$$A=\frac{2\ bd}{3}$$

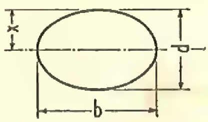
$$x=\frac{6d}{10}$$

$$y=\frac{3b}{8}$$

TABLE 22—FORMULAS FOR ELEMENTS OF SECTIONS—Concluded

Figure 12

Ellipse



$$A = \frac{\pi\, bd}{4}$$

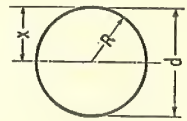
$$x = \frac{d}{2}$$

$$I = \frac{\pi\, bd^3}{64}$$

$$S = \frac{\pi\, bd^2}{32}$$

$$r = \frac{d}{4}$$

Figure 13



$$A = \pi\, R^2 = \frac{\pi d^2}{4}$$

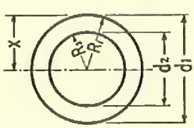
$$x = R = \frac{d}{2}$$

$$I = \frac{\pi R^4}{4} = \frac{\pi d^4}{64}$$

$$S = \frac{\pi R^3}{4} = \frac{\pi d^3}{32}$$

$$r = \frac{R}{2} = \frac{d}{4}$$

Figure 14



$$A = \pi\, (R_1^2 - R_2^2) = \frac{\pi(d_1^2 - d_2^2)}{4}$$

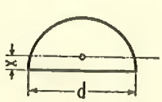
$$x = R_1 = \frac{d_1}{2}$$

$$I = \frac{\pi(R_1^4 - R_2^4)}{4} = \frac{\pi(d_1^4 - d_2^4)}{64}$$

$$S = \frac{\pi(R_1^4 - R_2^4)}{4R_1} = \frac{\pi(d_1^4 - d_2^4)}{32d_1}$$

$$r = \sqrt{\frac{R_1^2 + R_2^2}{4}} = \sqrt{\frac{d_1^2 + d_2^2}{16}}$$

Figure 15



$$A = \frac{\pi R^2}{2} = \frac{\pi d^2}{8}$$

$$I = 0.1098R^4 = 0.0069d^4$$

$$x = \frac{4R}{3\pi} = \frac{2d}{3\pi}$$

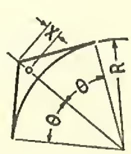


Figure 16

$$A = (\tan\Theta - \Theta)R^2$$

$$x = \left(\sec\Theta - \frac{\tan^2\Theta \sin\Theta}{3(\tan\Theta - \Theta)}\right)R$$

TECHNICAL DATA

ON

MISCELLANEOUS STRUCTURAL

PRODUCTS

TABLE 23—WEIGHT OF ALUMINUM AND STEEL SHEET

Thickness Inch	B & S Gage	Weight in lb./sq. ft.					Manufacturers' Standard Gage for Steel Sheet*
		3S	24S	52S	4S 61S	Steel	
0.2391	..	3.409	3.443	3.340	3.374	10.000	3
0.2294	3	3.270	3.303	3.204	3.237	.....	..
0.2242	..	3.196	3.229	3.132	3.164	9.375	4
0.2092	..	2.982	3.013	2.922	2.952	8.750	5
0.2043	4	2.913	2.942	2.854	2.883	.....	..
0.1943	..	2.770	2.798	2.714	2.742	8.125	6
0.1819	5	2.593	2.619	2.541	2.567	.....	..
0.1793	..	2.556	2.582	2.504	2.530	7.500	7
0.1644	..	2.344	2.367	2.296	2.320	6.875	8
0.1620	6	2.310	2.333	2.263	2.286	.....	..
0.1495	..	2.131	2.153	2.088	2.110	6.250	9
0.1443	7	2.057	2.078	2.016	2.036	.....	..
0.1345	..	1.917	1.937	1.879	1.898	5.625	10
0.1285	8	1.832	1.850	1.795	1.813	.....	..
0.1196	..	1.705	1.722	1.671	1.688	5.000	11
0.1144	9	1.631	1.647	1.598	1.614	.....	..
0.1046	..	1.491	1.506	1.461	1.476	4.375	12
0.1019	10	1.453	1.467	1.423	1.438	.....	..
0.0907	11	1.293	1.306	1.267	1.280	.....	..
0.0897	..	1.279	1.292	1.253	1.266	3.750	13
0.0808	12	1.152	1.164	1.129	1.140	.....	..
0.0747	..	1.065	1.076	1.043	1.054	3.125	14
0.0720	13	1.026	1.037	1.006	1.016	.....	..
0.0673	..	0.959	0.969	0.940	0.950	2.812	15
0.0641	14	0.914	0.923	0.895	0.905	.....	..
0.0598	..	0.853	0.861	0.835	0.844	2.500	16
0.0571	15	0.814	0.822	0.798	0.806	.....	..
0.0538	..	0.767	0.775	0.751	0.759	2.250	17
0.0508	16	0.724	0.732	0.710	0.717	.....	..
0.0478	..	0.681	0.688	0.668	0.675	2.000	18
0.0453	17	0.646	0.652	0.633	0.639	.....	..
0.0418	..	0.596	0.602	0.584	0.590	1.750	19
0.0403	18	0.575	0.580	0.563	0.569	.....	..
0.0359	19	0.512	0.517	0.501	0.507	1.500	20
0.0329	..	0.469	0.474	0.460	0.464	1.375	21
0.0320	20	0.456	0.461	0.447	0.452	.....	..
0.0299	..	0.426	0.431	0.418	0.422	1.250	22
0.0285	21	0.406	0.410	0.398	0.402	.....	..
0.0269	..	0.384	0.387	0.376	0.380	1.125	23

*The weights per square foot corresponding to these gage numbers are the same as for U. S. Standard Gage. The thicknesses are determined on the basis of a weight of 41.82 pounds per square foot per inch thick. Ref: Steel Product Manual, Carbon Steel Sheet, American Iron and Steel Institute, November, 1942.

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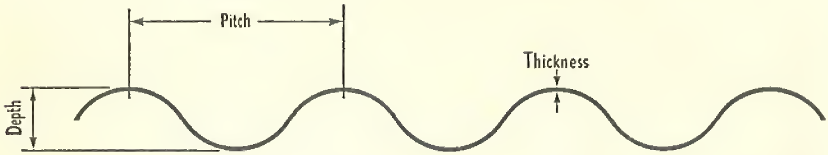
TABLE 24—CORRUGATED SHEET[1]



Elements of Section

B & S Gage	Thickness	Weight	12-inch width of corrugated sheet			
			Area	$I_{x\text{-}x}$	$S_{x\text{-}x}$	$r_{x\text{-}x}$
	Inches	Lb./sq. ft.	In.^{2}	In.^{4}	In.^{3}	Inches
Alcoa Industrial Roofing Sheet, Pitch=2.67 inches, Depth=⅞ inch						
20	0.0320	0.560	0.476	0.0423	0.097	0.298
Pitch=2.67 inches, Depth=¾ inch						
14	0.0641	1.094[2]	0.923	0.0649	0.173	0.266
16	0.0508	0.868[2]	0.732	0.0514	0.137	0.266
18	0.0403	0.669[2]	0.580	0.0408	0.109	0.266
20	0.0320	0.548[2]	0.461	0.0324	0.086	0.266
22	0.0253	0.434[2]	0.364	0.0256	0.068	0.266
Pitch=1.26 inches, Depth=⅜ inch						
16	0.0508	0.879[2]	0.744	0.0131	0.0697	0.133
18	0.0403	0.696[2]	0.590	0.0104	0.0553	0.133
20	0.0320	0.553[2]	0.468	0.0082	0.0439	0.133
22	0.0253	0.443[2]	0.370	0.0065	0.0347	0.133
24	0.0201	0.347[2]	0.294	0.0052	0.0276	0.133

[1]A variety of special types and sizes of corrugations and other thicknesses of sheet can be furnished.
[2]Weight given is for 3S alloy. Corrugated sheet can be furnished in other alloys.

TABLE 25—WEIGHTS AND AREAS OF SQUARE AND ROUND BARS

Weights given are for 14S
For other alloys, multiply by the following factors:
3S—0.980; 4S and 61S—0.970; 24S—0.990; 52S—0.960

Size	Square		Round	
Inches	Weight, lb./ft.	Area, sq. in.	Weight, lb./ft.	Area, sq. in.
0	0	0	0	0
1/16	0.005	0.0039	0.004	0.0031
1/8	0.019	0.0156	0.015	0.0123
3/16	0.043	0.0352	0.033	0.0276
1/4	0.076	0.0625	0.059	0.0491
5/16	0.118	0.0977	0.093	0.0767
3/8	0.170	0.1406	0.134	0.1104
7/16	0.232	0.1914	0.182	0.1503
1/2	0.303	0.2500	0.238	0.1963
9/16	0.383	0.3164	0.301	0.2485
5/8	0.473	0.3906	0.371	0.3068
11/16	0.572	0.4727	0.449	0.3712
3/4	0.681	0.5625	0.535	0.4418
13/16	0.799	0.6602	0.627	0.5185
7/8	0.926	0.7656	0.728	0.6013
15/16	1.063	0.8789	0.835	0.6903
1	1.210	1.0000	0.950	0.7854
1 1/16	1.366	1.1289	1.073	0.8866
1 1/8	1.531	1.2656	1.203	0.9940
1 3/16	1.706	1.4102	1.340	1.1075
1 1/4	1.891	1.5625	1.485	1.2272
1 5/16	2.084	1.7227	1.637	1.3530
1 3/8	2.288	1.8906	1.797	1.4849
1 7/16	2.500	2.0664	1.964	1.6230
1 1/2	2.723	2.2500	2.138	1.7671
1 9/16	2.954	2.4414	2.320	1.9175
1 5/8	3.195	2.6406	2.509	2.0739
1 11/16	3.446	2.8477	2.706	2.2365
1 3/4	3.706	3.0625	2.910	2.4053
1 13/16	3.975	3.2852	3.122	2.5802
1 7/8	4.254	3.5156	3.341	2.7612
1 15/16	4.542	3.7539	3.567	2.9483
2	4.840	4.0000	3.801	3.1416
2 1/16	5.147	4.2539	4.043	3.3410
2 1/8	5.464	4.5156	4.291	3.5466
2 3/16	5.790	4.7852	4.548	3.7583
2 1/4	6.126	5.0625	4.811	3.9761
2 5/16	6.471	5.3477	5.082	4.2000
2 3/8	6.825	5.6406	5.360	4.4301
2 7/16	7.189	5.9414	5.646	4.6664
2 1/2	7.563	6.2500	5.940	4.9087
2 9/16	7.945	6.5664	6.240	5.1572
2 5/8	8.338	6.8906	6.548	5.4119
2 11/16	8.739	7.2227	6.864	5.6727
2 3/4	9.151	7.5625	7.187	5.9396
2 13/16	9.571	7.9102	7.517	6.2126
2 7/8	10.001	8.2656	7.855	6.4918
2 15/16	10.441	8.6289	8.200	6.7771

(Continued on next page)

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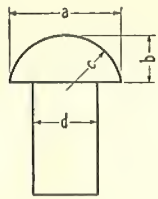
TABLE 25—WEIGHTS AND AREAS OF SQUARE AND ROUND BARS—Concluded

Weights given are for 14S
For other alloys, multiply by the following factors:
3S—0.980; 4S and 61S—0.970; 24S—0.990; 52S—0.960

Size	Square		Round	
Inches	Weight, lb./ft.	Area, sq. in.	Weight, lb./ft.	Area, sq. in.
3	10.890	9.0000	8.553	7.0686
3 1/16	11.348	9.3789	8.913	7.3662
3 1/8	11.816	9.7656	9.281	7.6699
3 3/16	12.294	10.1602	9.656	7.9798
3 1/4	12.781	10.5625	10.038	8.2958
3 5/16	13.277	10.9727	10.428	8.6180
3 3/8	13.783	11.3906	10.825	8.9462
3 7/16	14.298	11.8164	11.230	9.2806
3 1/2	14.823	12.2500	11.642	9.6212
3 9/16	15.357	12.6914	12.061	9.9678
3 5/8	15.900	13.1406	12.488	10.3206
3 11/16	16.453	13.5977	12.922	10.6796
3 3/4	17.016	14.0625	13.364	11.0447
3 13/16	17.588	14.5352	13.813	11.4159
3 7/8	18.169	15.0156	14.270	11.7933
3 15/16	18.760	15.5039	14.734	12.1768
4	19.360	16.0000	15.205	12.5664
4 1/16	19.970	16.5039	15.684	12.9622
4 1/8	20.589	17.0156	16.171	13.3641
4 3/16	21.218	17.5352	16.664	13.7721
4 1/4	21.856	18.0625	17.165	14.1863
4 5/16	22.503	18.5977	17.674	14.6066
4 3/8	23.160	19.1408	18.190	15.0330
4 7/16	23.827	19.6914	18.713	15.4656
4 1/2	24.503	20.2500	19.244	15.9044
4 9/16	25.188	20.8164	19.783	16.3492
4 5/8	25.883	21.3906	20.328	16.8002
4 11/16	26.587	21.9727	20.881	17.2574
4 3/4	27.301	22.5625	21.442	17.7206
4 13/16	28.024	23.1602	22.010	18.1900
4 7/8	28.756	23.7656	22.585	18.6655
4 15/16	29.498	24.3789	23.168	19.1472
5	30.250	25.0000	23.758	19.6350
5 1/16	31.011	25.6289	24.356	20.1289
5 1/8	31.781	26.2656	24.961	20.6290
5 3/16	32.561	26.9102	25.574	21.1353
5 1/4	33.351	27.5625	26.194	21.6476
5 5/16	34.149	28.2227	26.821	22.1661
5 3/8	34.958	28.8906	27.456	22.6907
5 7/16	35.775	29.5664	28.098	23.2215
5 1/2	36.603	30.2500	28.748	23.7584
5 9/16	37.439	30.9414	29.405	24.3014
5 5/8	38.285	31.6406	30.069	24.8505
5 11/16	39.141	32.3477	30.741	25.4059
5 3/4	40.006	33.0625	31.420	25.9673
5 13/16	40.880	33.7852	32.107	26.5349
5 7/8	41.764	34.5156	32.801	27.1086
5 15/16	42.657	35.2539	33.503	27.6884

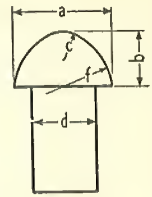
TABLE 26—DIMENSIONS OF STRUCTURAL RIVETS

MANUFACTURED HEADS



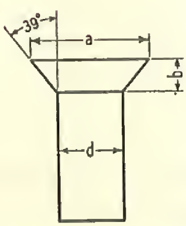
Button

Sizes up to ½ in.
a=1.75d
b=0.75d
c=0.885d



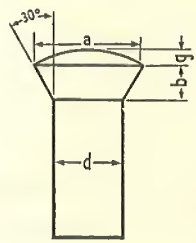
High Button (Am. Std.)

Sizes ½ in. and larger
a=1.5d +0.031 in.
b=0.75d+0.125 in.
c=0.75d−0.281 in.
f=0.75d+0.281 in.



Flat Countersunk

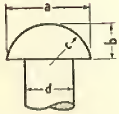
a=1.81d
b=0.50d



Oval Countersunk

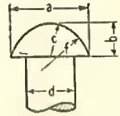
a=1.577d
b=0.50d
g=0.187d

DRIVEN HEADS



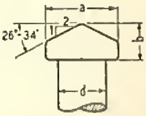
Button

Sizes up to ½ in.
a=1.75d
b=0.75d
c=0.885d



Button (Am. Std.)

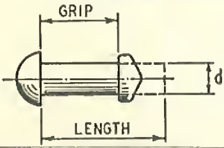
Sizes ½ in. and larger
a=1.5d +0.125 in.
b=0.638d+0.053 in.
c=0.638d+0.053 in.
f=0.956d+0.080 in.



Cone Point

a=1.5d
b=0.75d

TABLE 27—LENGTHS OF RIVETS FOR VARIOUS GRIPS

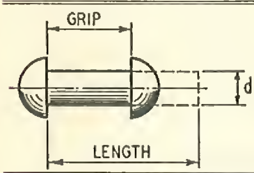


Hole diameter not more than 1/32 inch greater than rivet diameter.

LENGTHS OF RIVETS FOR CONE-POINT DRIVEN HEADS

Cone-point heads are dimensioned in Table 26, page 155.

Grip	d=1/4	d=5/16	d=3/8	d=1/2	d=5/8	d=3/4	d=7/8	d=1
1/8	7/16	1/2	9/16	11/16	13/16	1	1 1/8	1 1/4
1/4	5/8	5/8	11/16	13/16	15/16	1 1/8	1 1/4	1 3/8
3/8	13/16	13/16	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
1/2	15/16	1	1	1 1/8	1 5/16	1 3/8	1 1/2	1 5/8
5/8	1 1/8	1 1/8	1 3/16	1 1/4	1 7/16	1 1/2	1 5/8	1 3/4
3/4	1 1/4	1 5/16	1 5/16	1 3/8	1 9/16	1 11/16	1 3/4	1 7/8
7/8	1 7/16	1 1/2	1 1/2	1 9/16	1 11/16	1 13/16	1 15/16	2
1	1 5/8	1 5/8	1 5/8	1 11/16	1 13/16	1 15/16	2 1/16	2 1/8
1 1/8	...	1 3/4	1 13/16	1 7/8	2	2 1/8	2 3/16	2 5/16
1 1/4	...	2	2	2	2 1/8	2 1/4	2 3/8	2 1/2
1 3/8	...	...	2 1/8	2 3/16	2 1/4	2 3/8	2 1/2	2 5/8
1 1/2	...	...	2 1/4	2 5/16	2 7/16	2 9/16	2 5/8	2 3/4
1 5/8	...	...	...	2 7/16	2 9/16	2 11/16	2 3/4	2 7/8
1 3/4	...	...	...	2 5/8	2 11/16	2 13/16	2 15/16	3 1/16
1 7/8	...	...	...	2 3/4	2 7/8	2 15/16	3 1/16	3 3/16
2	...	...	...	2 15/16	3	3 1/8	3 3/16	3 5/16
2 1/8	...	...	...	...	3 1/8	3 1/4	3 5/16	3 1/2
2 1/4	...	...	...	...	3 5/16	3 7/16	3 1/2	3 5/8
2 3/8	...	...	...	...	3 7/16	3 9/16	3 5/8	3 3/4
2 1/2	...	...	...	...	3 9/16	3 11/16	3 3/4	3 7/8



LENGTHS OF RIVETS FOR BUTTON DRIVEN HEADS

Button driven heads are dimensioned in Table 26, page 155.

Grip	d=1/4	d=5/16	d=3/8	d=1/2	d=5/8	d=3/4	d=7/8	d=1
1/8	9/16	5/8	3/4	...	...	...	...	...
1/4	3/4	13/16	7/8	1	1 3/16	1 3/8	...	...
3/8	15/16	15/16	1 1/16	1 3/16	1 3/8	1 1/2	1 5/8	1 3/4
1/2	1 1/16	1 1/8	1 3/16	1 5/16	1 1/2	1 5/8	1 3/4	1 7/8
5/8	1 3/16	1 1/4	1 5/16	1 1/2	1 11/16	1 3/4	1 7/8	2
3/4	1 3/8	1 7/16	1 1/2	1 5/8	1 13/16	1 15/16	2	2 1/8
7/8	1 1/2	1 5/8	1 11/16	1 13/16	1 15/16	2 1/16	2 1/8	2 1/4
1	1 3/4	1 3/4	1 13/16	1 15/16	2 1/16	2 3/16	2 1/4	2 3/8
1 1/8	...	1 15/16	2	2 1/8	2 3/16	2 3/8	2 3/8	2 1/2
1 1/4	...	2 1/8	2 1/8	2 1/4	2 3/8	2 1/2	2 1/2	2 5/8
1 3/8	...	...	2 5/16	2 3/8	2 1/2	2 5/8	2 3/4	2 7/8
1 1/2	...	...	2 1/2	2 1/2	2 11/16	2 13/16	2 7/8	3
1 5/8	...	...	...	2 11/16	2 13/16	2 15/16	3	3 1/8
1 3/4	...	...	...	2 7/8	2 15/16	3 1/8	3 1/8	3 1/4
1 7/8	...	...	...	3	3 1/8	3 1/4	3 1/4	3 3/8
2	...	...	...	3 3/16	3 1/4	3 3/8	3 3/8	3 1/2
2 1/8	...	...	...	...	3 7/16	3 1/2	3 1/2	3 5/8
2 1/4	...	...	...	...	3 9/16	3 5/8	3 5/8	3 3/4
2 3/8	...	...	...	...	3 3/4	3 3/4	3 3/4	3 7/8
2 1/2	...	...	...	...	3 7/8	3 7/8	3 7/8	4

TABLE 28—WEIGHTS OF STRUCTURAL RIVETS

BUTTON HEAD

Weights given are for 17S

For A17S-T multiply by 0.980. For 53S multiply by 0.960

VALUES GIVEN IN POUNDS PER HUNDRED RIVETS

Length under head Inches	Diameter in inches										
	¼	5/16	⅜	7/16	½	⅝	¾	⅞	1	1⅛	1¼
Weight of → heads only	0.2	0.4	0.6	0.9	1.4	2.8	4.8	7.6	11.3	16.1	22.1
½	0.4	...	...	...	...	..	..	..	..	..	..
⅝	0.5	0.9	...	...	...	..	..	..	..	..	..
¾	0.6	1.0	1.4	...	...	..	..	..	..	..	..
⅞	0.6	1.1	1.6	2.2	...	..	..	..	..	..	..
1	0.7	1.2	1.7	2.4	3.4	..	..	..	..	..	..
1⅛	0.8	1.3	1.9	2.6	3.6	..	..	..	..	..	..
1¼	0.8	1.4	2.0	2.8	3.9	7	..	..	..	..	..
1⅜	0.9	1.5	2.1	3.0	4.1	7	..	..	..	..	..
1½	0.9	1.6	2.3	3.2	4.4	7	12	..	..	..	..
1⅝	1.0	1.7	2.4	3.4	4.6	8	12	..	..	..	..
1¾	1.1	1.8	2.6	3.6	4.9	8	13	18	..	..	..
1⅞	1.1	1.9	2.7	3.8	5.1	9	13	19	..	..	..
2	1.2	2.0	2.8	3.9	5.4	9	14	20	27	..	..
2⅛	1.2	2.0	3.0	4.1	5.6	9	14	21	28	..	..
2¼	1.3	2.1	3.1	4.3	5.9	10	15	21	29	39	..
2⅜	1.4	2.2	3.3	4.5	6.1	10	15	22	30	40	..
2½	1.4	2.3	3.4	4.7	6.4	11	16	23	31	41	53
2⅝	1.5	2.4	3.5	4.9	6.6	11	17	24	32	42	55
2¾	1.6	2.5	3.7	5.1	6.9	11	17	24	33	44	56
2⅞	1.6	2.6	3.8	5.3	7.1	12	18	25	34	45	58
3	1.7	2.7	3.9	5.5	7.3	12	18	26	35	46	59
3⅛	1.7	2.8	4.1	5.7	7.6	13	19	27	36	47	61
3¼	1.8	2.9	4.2	5.8	7.8	13	19	27	37	49	62
3⅜	1.9	3.0	4.4	6.0	8.1	13	20	28	38	50	64
3½	1.9	3.1	4.5	6.2	8.3	14	20	29	39	51	65
3⅝	2.0	3.2	4.6	6.4	8.6	14	21	30	40	52	67
3¾	2.0	3.3	4.8	6.6	8.8	14	22	30	41	54	69
3⅞	2.1	3.4	4.9	6.8	9.1	15	22	31	42	55	70
4	2.2	3.5	5.1	7.0	9.3	15	23	32	43	56	72
4⅛	2.2	3.6	5.2	7.2	9.6	16	23	33	44	58	73
4¼	2.3	3.7	5.3	7.4	9.8	16	24	33	45	59	75
4⅜	2.4	3.8	5.5	7.6	10.1	16	24	34	46	60	76
4½	2.4	3.9	5.6	7.7	10.3	17	25	35	47	61	78
4⅝	2.5	4.0	5.8	7.9	10.6	17	25	36	48	63	79
4¾	2.5	4.1	5.9	8.1	10.8	18	26	36	49	64	81
4⅞	2.6	4.2	6.0	8.3	11.1	18	27	37	50	65	82
5	2.7	4.3	6.2	8.5	11.3	18	27	38	51	66	84

TABLE 29—SHEARING AND BEARING AREAS OF DRIVEN RIVETS

Cold-Driven Rivets

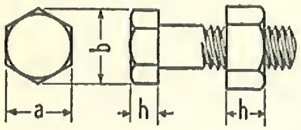
	Nominal Rivet Diameter, Inches	¼	5/16	⅜	7/16	½	9/16	⅝	¾
	Recommended Hole Diameter, Inches	0.257	0.323	0.386	0.453	0.516	0.578	0.641	0.766
	Corresponding Drill Size	F	P	W	29/64	33/64	37/64	41/64	49/64
	Corresponding Single Shear Area, Sq. In.	0.05187	0.08194	0.1170	0.1612	0.2091	0.2624	0.3227	0.4608
Bearing Area, Sq. In., For Various Sheet and Plate Thicknesses	0.064	0.01645	0.0207	......	......	......	......	......	......
	0.081	0.02082	0.0262	0.0313	......	......	......	......	......
	0.102	0.02621	0.0329	0.0394	0.0462	......	......	......	......
	⅛	0.03213	0.0404	0.0483	0.0566	0.0645	0.0723	0.0801	0.0958
	5/32	0.04016	0.0505	0.0603	0.0708	0.0806	0.0903	0.1002	0.1197
	3/16	0.04819	0.0606	0.0724	0.0849	0.0968	0.1084	0.1202	0.1436
	7/32	0.05622	0.0707	0.0844	0.0991	0.1129	0.1264	0.1402	0.1676
	¼	0.06425	0.0808	0.0965	0.1133	0.1290	0.1445	0.1603	0.1915
	5/16	....	0.1009	0.1206	0.1416	0.1613	0.1806	0.2003	0.2394
	⅜	....	......	0.1448	0.1699	0.1935	0.2168	0.2404	0.2873
	7/16	....	......	......	0.1982	0.2258	0.2529	0.2804	0.3351
	½	....	......	......	......	0.2580	0.2890	0.3205	0.3830
	9/16	....	......	......	......	......	0.3251	0.3606	0.4309
	⅝	....	......	......	......	......	......	0.4006	0.4788
	11/16	....	......	......	......	......	......	0.4407	0.5266
	¾	....	......	......	......	......	......	......	0.5745
	13/16	....	......	......	......	......	......	......	......
	⅞	....	......	......	......	......	......	......	......
	1	....	......	......	......	......	......	......	......

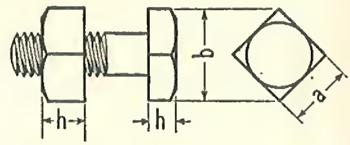
TABLE 29—SHEARING AND BEARING AREAS OF DRIVEN RIVETS—Concluded

Hot-Driven Rivets

Nominal Rivet Diameter, Inches		3/8	7/16	1/2	9/16	5/8	3/4	7/8	1
Recommended Hole Diameter, Inches		0.397	0.469	0.531	0.594	0.656	0.781	0.922	1.063
Corresponding Drill Size		X	15/32	17/32	19/32	21/32	25/32	59/64	1 1/16
Corresponding Single Shear Area, Sq. In.		0.1238	0.1728	0.2215	0.2771	0.3380	0.4791	0.6677	0.8875
Bearing Area, Sq. In., For Various Sheet and Plate Thicknesses	0.064	......	......	......	......	......	......	......	......
	0.081	0.0322	......	......	......	......	......	......	......
	0.102	0.0405	0.0478	......	......	......	......	......	......
	1/8	0.0496	0.0586	0.0664	0.0742	0.0820	0.0976	0.1153	0.1329
	5/32	0.0620	0.0733	0.0830	0.0928	0.1025	0.1220	0.1441	0.1661
	3/16	0.0744	0.0879	0.0996	0.1114	0.1230	0.1464	0.1729	0.1993
	7/32	0.0868	0.1026	0.1162	0.1299	0.1435	0.1708	0.2017	0.2325
	1/4	0.0993	0.1173	0.1328	0.1485	0.1640	0.1953	0.2305	0.2658
	5/16	0.1241	0.1466	0.1659	0.1856	0.2050	0.2441	0.2881	0.3322
	3/8	0.1489	0.1759	0.1991	0.2228	0.2460	0.2929	0.3458	0.3986
	7/16	......	0.2052	0.2323	0.2599	0.2870	0.3417	0.4034	0.4651
	1/2	......	......	0.2655	0.2970	0.3280	0.3905	0.4610	0.5315
	9/16	......	......	......	0.3341	0.3690	0.4393	0.5186	0.5979
	5/8	......	......	......	......	0.4100	0.4881	0.5763	0.6644
	11/16	......	......	......	......	0.4510	0.5369	0.6339	0.7308
	3/4	......	......	......	......	......	0.5858	0.6915	0.7973
	13/16	......	......	......	......	......	......	0.7491	0.8637
	7/8	......	......	......	......	......	......	0.8068	0.9301
	1	......	......	......	......	......	......	......	1.063

TABLE 30—DIMENSIONS OF ROUGH AND SEMIFINISHED BOLTS





All dimensions in inches

Diameter of bolt	Threads per inch	Shank			Head					Nut				
		Diameter at root of thread	Gross area in shank	Area at root of thread	Hexagonal		Hex. or square	Square		Hexagonal		Hex. or square	Square	
			Sq. in.	Sq. in.	a	b	h	a	b	a	b	h	a	b
1/4	20	0.1850	0.049	0.027	3/8	0.43	11/64	3/8	0.53	7/16	0.51	7/32	7/16	0.62
5/16	18	0.2403	0.077	0.045	1/2	0.58	13/64	1/2	0.71	9/16	0.55	17/64	9/16	0.80
3/8	16	0.2938	0.111	0.068	9/16	0.65	1/4	9/16	0.80	5/8	0.72	21/64	5/8	0.88
7/16	14	0.3447	0.150	0.093	5/8	0.72	19/64	5/8	0.88	3/4	0.87	3/8	3/4	1.06
1/2	13	0.4001	0.196	0.126	3/4	0.87	21/64	3/4	1.06	13/16	0.94	7/16	13/16	1.15
9/16	12	0.4542	0.249	0.162	7/8	1.01	3/8	7/8	1.24	7/8	1.01	1/2	7/8	1.24
5/8	11	0.5069	0.307	0.202	15/16	1.08	27/64	15/16	1.33	15/16	1.08	35/64	15/16	1.33
3/4	10	0.6201	0.442	0.302	1 1/8	1.30	1/2	1 1/8	1.59	1 1/8	1.30	21/32	1 1/8	1.59
7/8	9	0.7307	0.601	0.419	1 5/16	1.52	19/32	1 5/16	1.86	1 5/16	1.52	49/64	1 5/16	1.86
1	8	0.8376	0.785	0.551	1 1/2	1.73	21/32	1 1/2	2.12	1 1/2	1.73	7/8	1 1/2	2.12
1 1/8	7	0.9394	0.994	0.693	1 11/16	1.95	3/4	1 11/16	2.39	1 11/16	1.95	1	1 11/16	2.39
1 1/4	7	1.0644	1.227	0.890	1 7/8	2.17	27/32	1 7/8	2.65	1 7/8	2.17	1 3/32	1 7/8	2.65

TABLE 31—APPROXIMATE WEIGHT OF ROUGH AND SEMIFINISHED HEXAGON HEAD BOLTS

Weights in pounds per hundred bolts of alloy 24S

Length under head Inches	Diameter in inches											
	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1	1⅛	1¼
Weight of heads only →	0.21	0.44	0.69	1.01	1.61	2.50	3.23	5.53	8.92	12.89	18.69	25.90
¼	0.30	....	....	....	....	....	....	....	.....	.....	.....	.....
½	0.40	0.75	1.13	1.62	2.41	3.52	....	....	.....	.....	.....	.....
¾	0.49	0.90	1.35	1.92	2.81	4.03	5.13	8.31	.....	.....	.....	.....
1	0.61	1.08	1.60	2.26	3.21	4.54	5.77	9.24	14.03	19.57	27.11	.....
1¼	0.73	1.27	1.87	2.63	3.70	5.16	6.40	10.17	15.30	21.23	29.21	39.11
1½	0.85	1.46	2.15	3.00	4.19	5.77	7.04	11.10	16.58	22.90	31.31	41.75
1¾	0.96	1.63	2.39	3.34	4.67	6.39	7.92	12.19	17.97	24.57	33.41	44.40
2	1.08	1.82	2.66	3.71	5.16	7.00	8.68	13.29	19.47	26.24	35.53	47.05
2¼	1.18	1.99	2.94	4.08	5.64	7.61	9.44	14.39	20.85	28.49	37.63	49.70
2½	1.30	2.18	3.21	4.45	6.03	8.23	10.19	15.48	22.35	30.45	39.74	52.31
2¾	1.42	2.36	3.48	4.82	6.61	8.84	10.95	16.58	23.85	32.12	42.60	55.00
3	1.54	2.55	3.75	5.19	7.10	9.46	11.71	17.67	25.34	34.08	45.08	57.60
3¼	1.66	2.74	3.98	5.50	7.50	9.98	12.35	18.77	26.84	36.04	47.19	61.45
3½	1.78	2.93	4.25	5.87	7.99	10.58	13.11	19.87	28.34	38.01	49.68	64.51
3¾	1.90	3.12	4.52	6.24	8.47	11.20	13.86	20.97	29.84	39.96	52.15	67.52
4	2.02	3.31	4.80	6.61	8.95	11.81	14.62	22.08	31.34	41.93	54.64	70.60
4¼	2.14	3.49	5.07	6.98	9.44	12.42	15.38	23.01	32.64	43.59	56.74	72.81
4½	2.26	3.68	5.34	7.35	9.93	13.04	16.14	24.11	34.14	45.55	59.22	75.89
4¾	2.38	3.87	5.61	7.72	10.41	13.66	16.90	25.21	35.64	47.50	61.69	78.92
5	2.50	4.06	5.88	8.10	10.89	14.26	17.66	26.31	37.14	49.45	64.19	82.00

TABLE 32—APPROXIMATE WEIGHT OF ROUGH AND SEMIFINISHED HEXAGON NUTS

Weights in pounds per hundred nuts of alloy 24S

Size Inches	¼	5⁄16	⅜	7⁄16	½	9⁄16	⅝	¾	⅞	1	1⅛	1¼
Weight per hundred	0.26	0.53	0.75	1.27	1.65	2.09	3.09	4.33	6.88	10.26	14.85	20.05

TABLE 33—DIMENSIONS AND ELEMENTS OF SECTIONS OF PIPE

Nominal Pipe Size, Inch	Schedule Number‡	Outside Diameter, Inch	Inside Diameter, Inch	Wall Thickness, Inch	Weight per Linear Foot Pounds§	Cross-Sectional Wall Area Sq. Ins.	Moment of Inertia Inches⁴	Section Modulus Inches³	Radius of Gyration Inches
1/8	40*	.405	.269	.068	.085	0.0720	0.0011	0.0053	0.1215
	80†	.405	.215	.095	.109	0.0925	0.0012	0.0060	0.1146
1/4	40*	.540	.364	.088	.147	0.1250	0.0033	0.0123	0.1628
	80†	.540	.302	.119	.185	0.1574	0.0038	0.0139	0.1547
3/8	40*	.675	.493	.091	.196	0.1670	0.0073	0.0216	0.2090
	80†	.675	.423	.126	.256	0.2173	0.0086	0.0255	0.1992
1/2	40*	.840	.622	.109	.294	0.2503	0.0171	0.0407	0.2613
	80†	.840	.546	.147	.376	0.3200	0.0201	0.0478	0.2505
3/4	40*	1.050	.824	.113	.391	0.3326	0.0370	0.0705	0.3337
	80†	1.050	.742	.154	.510	0.4335	0.0448	0.0853	0.3214
1	40*	1.315	1.049	.133	.581	0.4939	0.0873	0.1328	0.4205
	80†	1.315	.957	.179	.751	0.6388	0.1056	0.1606	0.4066
1 1/4	40*	1.660	1.380	.140	.786	0.6685	0.1947	0.2346	0.5397
	80†	1.660	1.278	.191	1.037	0.8815	0.2418	0.2913	0.5238
1 1/2	40*	1.900	1.610	.145	.940	0.7995	0.3099	0.3262	0.6226
	80†	1.900	1.500	.200	1.256	1.0681	0.3912	0.4118	0.6052
2	40*	2.375	2.067	.154	1.264	1.0745	0.6657	0.5606	0.7871
	80†	2.375	1.939	.218	1.737	1.4773	0.8679	0.7309	0.7665
2 1/2	40*	2.875	2.469	.203	2.004	1.7041	1.530	1.064	0.9474
	80†	2.875	2.323	.276	2.650	2.2535	1.924	1.339	0.9241
3	40*	3.500	3.068	.216	2.621	2.2285	3.017	1.724	1.164
	80†	3.500	2.900	.300	3.547	3.0159	3.894	2.225	1.136
3 1/2	40*	4.000	3.548	.226	3.151	2.6795	4.788	2.394	1.337
	80†	4.000	3.364	.318	4.326	3.6784	6.281	3.140	1.307
4	40*	4.500	4.026	.237	3.733	3.1740	7.232	3.214	1.510
	80†	4.500	3.826	.337	5.183	4.4074	9.611	4.272	1.477
5	40*	5.563	5.047	.258	5.057	4.2999	15.16	5.451	1.878
	80†	5.563	4.813	.375	7.188	6.1120	20.67	7.432	1.839
6	40*	6.625	6.065	.280	6.564	5.5814	28.14	8.496	2.246
	80†	6.625	5.761	.432	9.884	8.4050	40.49	12.22	2.195
8	30	8.625	8.071	.277	8.543	7.2646	63.35	14.69	2.953
	40	8.625	7.981	.322	9.878	8.3992	72.49	16.81	2.938
	80	8.625	7.625	.500	15.01	12.7628	105.7	24.51	2.878
10		10.750	10.192	.279	10.79	9.1779	125.8	23.41	3.704
	30	10.750	10.136	.307	11.84	10.0720	137.4	25.57	3.694
	40	10.750	10.020	.365	14.00	11.9082	160.7	29.90	3.674
	60	10.750	9.750	.500	18.93	16.1007	211.9	39.43	3.628
12		12.750	12.000	.375	17.14	14.5789	279.3	43.81	4.377
		12.750	11.750	.500	22.63	19.2423	361.5	56.71	4.335

*Also designated as Standard Pipe.
†Also designated as Extra-Heavy or Extra-Strong Pipe.
‡Schedule Numbers conform to American Standard for Wrought Iron and Wrought Steel Pipe, ASA B36.10.
§Weights calculated for 61S. For 3S multiply by 1.010.
All calculations based on nominal dimensions.

SPECIFICATIONS, TOLERANCES AND COMMERCIAL SIZES OF STRUCTURAL MATERIAL

TABLE 34—SPECIFICATIONS FOR ALUMINUM ALLOYS USED FOR STRUCTURAL MATERIAL

	Wrought alloys	Federal[1]	Army[1]	Navy[1]	S.A.E.	A.S.T.M.[2]
3S	Sheet and plate	QQ-A-359	....	47A4	29	B209 B178
	Bar, rod, wire and shapes	QQ-A-356	....	46A6	29	B221
	Tubing	WW-T-788	....	44T20	29	B210
	Rivets and rivet wire and rod	......	....	43R5	..	......
14S	Forgings	QQ-A-367	....	46A7	260	......
	Extrusions	......	....	....	260	B221
24S	Sheet and plate	QQ-A-355	....	47A10	24	B209
	Bar, rod and shapes	QQ-A-354	....	46A9	24	B211 B221
	Tubing	WW-T-785	....	44T28	24	B210
	Rivets	......	....	....	24	......
	Bolts, nuts, studs and tap rivets	FF-B-571	....	43B11	...	......
	Machine screws	FF-S-91	....	42S5	...	......
Alc. 24S	Sheet and plate	QQ-A-362	....	....	240	B209
A51S	Forgings	QQ-A-367	....	46A7	280	......
52S	Sheet and plate	QQ-A-318	....	47A11	201	B209 B178
	Bar, rod and wire	QQ-A-315	....	46A11	201	B211
	Tubing	WW-T-787	....	....	201	B210
53S	Rivets	......	....	43R5	...	......
	Rivet wire	......	....	43R5	...	......
61S	Sheet and plate	QQ-A-327	....	47A12	281	B209 B178
	Bar, rod and shapes	QQ-A-325	....	46A10	281	B211 B221
	Tubing	WW-T-789	....	44T30	281	B210
	Sand castings					
43		QQ-A-601-3	....	46A1	35	B26
195		QQ-A-601-3	....	46A1	38	B26
214		QQ-A-601-3	....	46A1	320	B26
220		......	57-72-6	....	324	B26
356		QQ-A-601-3	....	46A1	323	B26

[1]Revisions of Federal, Army, and Navy specifications are designated by a letter following the specification number. Purchasers should specify that material conform with the issue of the specifications in effect at the date of the proposal under which the contract was issued.
[2]A.S.T.M. specifications have a suffix (such as -49T) indicating the year of issue.

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TABLE 35—MECHANICAL PROPERTIES SPECIFICATIONS—3S, 4S, 52S SHEET AND PLATE

Grade and Temper	Tensile Strength, Lb./Sq. In. Minimum, Except for Soft (O) Temper	Minimum Elongation,[1] Per Cent in 2 Inches — Thickness,[3] Inches				
		3.000–.501	.500–.250	.249–.162	.161–.114	.113–.051
3S-O	19,000 (2)	23	23	25	25	25
3S-H12 or H22	17,000	10	9	8	7	6
3S-H14 or H24	19,500	10	8	7	6	5
3S-H16 or H26	24,000	..	..	..	4	4
3S-H18 or H28	27,000	..	..	..	4	4
4S-O	29,000 (2)	16	16	18	18	18
4S-H32	28,000	..	..	6	6	5
4S-H34	32,000	..	..	5	5	4
4S-H36	35,000	..	..	..	4	4
4S-H38	38,000	..	..	..	4	4
52S-O	31,000 (2)	18	18	20	20	20
52S-H32	31,000	12	9	9	9	7
52S-H34	34,000	10	10	7	7	6
52S-H36	37,000	..	..	..	4	4
52S-H38	39,000	..	..	..	4	4

[1]Test specimens taken parallel to direction of rolling from flat and coiled sheet in H12, H32, H14 and H34 tempers.

[2]Maximum. So specified to insure complete annealing.

[3]Maximum thickness for H12, H22 and H32 is 1 15/16 inch; for H14, H24 and H34 is 15/16 inch; for H16, H26 and H36 is 0.162 inch; and for H18, H28 and H38 is 0.128 inch. Special surface finishes may further restrict the thicknesses.

TABLE 36—MECHANICAL PROPERTIES SPECIFICATIONS—14S ALLOY PRODUCTS

Material	Thickness, Inch	Tensile Strength, Lb./Sq. In. Minimum, Except for 14S–O	Yield Strength (Offset=0.2%), Lb./Sq. In. Minimum	Elongation, Per Cent in 2 Inches or in 4D, Minimum
Sheet and Plate				
Alclad 14S-T3 Flat Sheet	0.040–0.249	57,000 (1)	36,000 (1)	15
Alclad 14S-T4 Plate	0.250–0.499	57,000 (1)	36,000 (1)	15
	0.500–1.000	58,000 (1)	34,000	15
Alclad 14S-T6 Flat Sheet	0.040–0.249	64,000	57,000	8
Plate	0.250–0.499	64,000	57,000	8
	0.500–1.000	67,000	59,000	6
Extruded Rods, Bars and Shapes				
14S-T4	All	50,000	35,000 (1)	12
14S-T6	0.125–0.499	60,000	53,000	7
	0.500–0.749	64,000 (1)	58,000 (1)	7
	0.750 and over			
	Area 25 sq. in., max.	68,000 (1)	60,000 (1)	7
	Area over 25 to 32 sq. in.	68,000 (1)	58,000 (1)	6
Shapes (rolled)				
14S-T4	0.125 and over	55,000	32,000	16
14S-T6	0.170 and over	65,000	55,000	8

[1]Flat sheet and plate heat treated by the user cannot be required to have a yield strength higher than 34,000 pounds per square inch. Extruded shapes reheat treated by the user cannot be required to have a yield strength higher than 29,000 pounds per square inch; those reheat treated and aged by the user, regardless of thickness, cannot be required to develop tensile and yield strengths higher than 60,000 and 53,000 pounds per square inch, respectively.

TABLE 37—MECHANICAL PROPERTIES SPECIFICATIONS—24S ALLOY PRODUCTS

Material	Thickness, Inches	Tensile Strength, Lb./Sq. In. Minimum, Except for 24S-O	Yield Strength (Offset=0.2%), Lb./Sq. In. Minimum	Elongation, Per Cent in 2 Inches or in 4D, Minimum
Sheet and Plate				
24S-T3 Flat Sheet	0.052–0.128	64,000 (1)	42,000 (1)	17
	0.129–0.249	64,000 (1)	42,000 (1)	15
24S-T4 Plate	0.250–0.500	64,000	40,000	12
	0.501–1.000	62,000	40,000	8
	1.001–1.500	60,000	40,000	7
	1.501–2.000	60,000	40,000	6
	2.001–3.000	56,000	40,000	4
Alclad 24S-T3 Flat Sheet	0.021–0.063	59,000 (1)	39,000 (1)	15
	0.064–0.128	62,000 (1)	40,000 (1)	15
	0.129–0.249	62,000 (1)	40,000 (1)	13
Alclad 24S-T4 Plate	0.250–0.499	62,000	40,000	11
	0.500–1.000	62,000	40,000	8
	1.001–1.500	60,000	40,000	7
	1.501–2.000	60,000	40,000	6
	2.001–3.000	56,000	40,000	4
Wire, Rod, Bar and Shapes				
24S-T4				
Wire	up to 0.124	62,000	....	..
Wire, Rods and Bars (rolled or cold finished)	0.125–5.500	62,000	40,000	14
Rods, Bars and Shapes (extruded)	Section thickness:			
	0.050 to 0.249	57,000 (1)	42,000 (1)	12
	0.250 to 0.749	60,000 (1)	44,000 (1)	12
	0.750 to 1.499	65,000 (1)	46,000 (1)	10
	1.500 and over			
	Area 25 sq. in. max.	70,000 (1)	52,000 (1)	10
	Area over 25 to 32 sq. in	68,000 (1)	48,000 (1)	8
Tubing				
24S-T3	Diameter ¼″ to 2″			
	Wall thickness:			
	0.018–0.024	64,000	42,000 (1)	10
	0.025–0.049	64,000	42,000 (1)	12
	0.050–0.259	64,000	42,000 (1)	14
	0.260–0.500	64,000	42,000 (1)	16
	Diameter greater than 2″ to 8″			
	Wall thickness:			
	0 025–0.259	64,000	42,000 (1)	10
	0.260–0.500	64,000	42,000 (1)	12

[1]Flat sheet in 24S heat treated by the user may have minimum tensile and yield strengths of 62,000 and 40,000 psi, respectively. Alclad 24S flat sheet up to 0.063 inch thick, when heat treated by the user, may have minimum tensile and yield strengths of 58,000 and 37,000 psi, respectively, while that 0.064 inch or thicker may have minimum strengths of 61,000 and 38,000 psi, respectively. Tubing heat treated by the user may have a minimum yield strength of 40,000 psi, and extruded shapes, minimum tensile and yield strengths of 57,000 and 38,000 psi, respectively.

TABLE 38—MECHANICAL PROPERTIES SPECIFICATIONS—61S ALLOY PRODUCTS

Material	Thickness, Inches	Tensile Strength, Lb./Sq. In. Minimum, Except for 61S-O	Yield Strength (Offset = 0.2%), Lb./Sq. In. Minimum	Elongation, Per Cent in 2 Inches or in 4D, Minimum
Sheet and Plate				
61S-T4	0.021–0.249	30,000	16,000	16
	0.250–1.000	30,000	16,000	18
	1.001–3.000	30,000	16,000	16
61S-T6	0.021–0.249	42,000	35,000	10
	0.250–0.500	42,000	35,000	10
	0.501–1.000	42,000	35,000	9
	1.001–2.000	42,000	35,000	8
	2.001–3.000	42,000	35,000	6
Tubing				
61S-T4	Diameter ¼″ to 2″ Wall thickness:			
	0.025–0.049	30,000	16,000	16
	0.050–0.259	30,000	16,000	18
	0.260–0.500	30,000	16,000	20
	Diameter greater than 2″ to 8″ Wall thickness:			
	0.025–0.049	30,000	16,000	14
	0.050–0.259	30,000	16,000	16
	0.260–0.500	30,000	16,000	18
61S-T6	Diameter ¼″ to 2″ Wall thickness:			
	0.025–0.049	42,000	35,000	10
	0.050–0.259	42,000	35,000	12
	0.260–0.500	42,000	35,000	14
	Diameter greater than 2″ to 8″ Wall thickness:			
	0.025–0.049	42,000	35,000	8
	0 050–0.259	42,000	35,000	10
	0.260–0.500	42,000	35,000	12

TABLE 38—MECHANICAL PROPERTIES SPECIFICATIONS—61S ALLOY PRODUCTS—Concluded

Material	Thickness, Inches	Tensile Strength, Lb./Sq. In. Minimum, Except for 61S-O	Yield Strength (Offset = 0.2%), Lb./Sq. In. Minimum	Elongation, Per Cent in 2 Inches or in 4D, Minimum
Wire, Rods, Bars and Shapes				
61S-T4				
Wire	up to 0.124	30,000	......	..
Wire, Rods, Bars and Shapes (rolled or cold finished)	0.125–3.000	30,000	16,000	18
Rods, Bars and Shapes (extruded)	All sizes	26,000	16,000	16
61S-T6				
Wire	up to 0.124	42,000	......	..
Wire, Rods, Bars and Shapes (rolled or cold finished)	0.125–3.000	42,000	35,000	10
Rods, Bars and Shapes (extruded)	All sizes	38,000	35,000	10

TABLE 39—MECHANICAL PROPERTIES SPECIFICATIONS—ALUMINUM ALLOY DIE FORGINGS[1, 2]

Material	Tensile Strength, Lb./Sq. In. Minimum	Yield Strength (Offset = 0.2%) Lb./Sq. In. Minimum	Elongation, Per Cent in 2 Inches Minimum	Brinell Hardness, 500-kg. Load 10-mm. Ball Minimum
14S-T4	55,000	30,000	16.0	100
14S-T6	65,000	55,000	10.0	125
A51S-T6	44,000	37,000	14.0	90

[1]These properties apply to forgings up to 4 inches in diameter or thickness.

[2]Values obtained from standard half-inch diameter test specimens with axis of specimen parallel to direction of grain flow. Values in compression are at least equal to those in tension.

TABLE 40—COMMERCIAL TOLERANCES FOR THICKNESS OF FLAT 3S SHEET AND PLATE

Tolerance, Plus or Minus, Inch

Thickness, Inches	Width, Inches						
	Up to 18, incl.	Over 18 through 36	Over 36 through 54	Over 54 through 72	Over 72 through 90	Over 90 through 102	Over 102 through 132
0.046 to 0.068	0.0025	0.003	0.004	0.005	0.007	.....	.....
0.069 to 0.076	0.0025	0.003	0.004	0.006	0.008	.....	.....
0.077 to 0.096	0.003	0.003	0.004	0.006	0.008	.....	.....
0.097 to 0.108	0.0035	0.004	0.005	0.007	0.009	0.010	.....
0.109 to 0.140	0.0045	0.0045	0.005	0.007	0.009	0.010	.....
0.141 to 0.172	0.006	0.006	0.008	0.009	0.011	0.012	.....
0.173 to 0.203	0.007	0.007	0.009	0.011	0.013	0.015	.....
0.204 to 0.249	0.009	0.009	0.011	0.013	0.015	0.017	.....
0.250 to 0.320	0.013	0.013	0.013	0.015	0.017	0.020	.....
0.321 to 0.438	0.019	0.019	0.019	0.019	0.023	0.026	0.026
0.439 to 0.625	0.025	0.025	0.025	0.025	0.030	0.035	0.035
0.626 to 0.875	0.030	0.030	0.030	0.030	0.037	0.045	0.045
0.876 to 1.125	0.035	0.035	0.035	0.035	0.045	0.055	0.055
1.126 to 1.375	0.040	0.040	0.040	0.040	0.052	0.065	0.065
1.376 to 1.625	0.045	0.045	0.045	0.045	0.060	0.075	0.075
1.626 to 1.875	0.052	0.052	0.052	0.052	0.070	0.088	0.088
1.876 to 2.250	0.060	0.060	0.060	0.060	0.080	0.100	0.100
2.251 to 2.750	0.075	0.075	0.075	0.075	0.100	0.125	.....
2.751 to 3.000	0.090	0.090	0.090	0.090	0.120	0.150	.....

TABLE 41—COMMERCIAL TOLERANCES FOR WIDTH AND LENGTH OF SHEARED FLAT SHEET, ALL ALLOYS

Width Tolerance, Plus or Minus, Inch

Thickness, Inch	Widths 1/4″ through 4″	Widths over 4″ through 18″	Widths over 18″ through 36″	Widths over 36″ through 54″	Widths over 54″ through 72″	Widths over 72″ through 102″
0.249 to 0.103	..	3/32 (2)	1/8	3/16	3/16	1/4
0.102 to 0.006	1/32 (1)	1/16	3/32	1/8	5/32	3/16

Length Tolerance, Plus or Minus, Inch

Thickness, Inch	Lengths through 18″	Lengths over 18″ through 48″	Lengths over 48″ through 120″	Lengths over 120″ through 180″	Lengths over 180″ through 540″
0.249–0.006	1/16	3/32	1/8	5/32	1/4

[1]For widths of 4 inches or less the maximum thickness of flat sheet which can be sheared commercially is 0.093 inch. Thicker sheet is sawed.
[2]For flat sheet in thicknesses of 0.201 inch to 0.249 inch the minimum width which can be sheared is 5 inches. Narrower widths must be sawed.

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TABLE 42—COMMERCIAL TOLERANCES FOR WIDTH AND LENGTH OF SHEARED PLATE, ALL ALLOYS

Tolerance, Plus Only, Inch

Thickness,[1] Inch	Width Tolerance[1]	Length Tolerance		
		Lengths through 12 ft.	Lengths over 12 ft. through 20 ft.	Lengths over 20 ft. through 45 ft.
1.000 to 0.501 0.500 to 0.250	1/2 3/8	1/2 3/8	9/16 7/16	5/8 1/2

[1]For limits for shearing plate see Note 2 to Tables 70 to 73.

TABLE 43—COMMERCIAL TOLERANCES FOR WIDTH AND LENGTH OF SAWED SHEET AND PLATE, ALL ALLOYS

Tolerance, Plus or Minus, Inch

Thickness, Inches	Dimensions through 10″	Dimensions over 10″ through 36″	Dimensions over 36″ through 60″	Dimensions over 60″ through 130″
Up to 3	1/32	1/16	3/32	3/32

TABLE 44—COMMERCIAL TOLERANCES FOR ROLLED STRUCTURAL SHAPES

Dimensions	Tolerance
Thickness of section	Plus or minus 2½ per cent of nominal thickness—minimum tolerance: ±0.010 inch.
Over-all dimensions. Length of leg of angles or zees.	Plus or minus 2½ per cent of nominal—minimum tolerance: ±1/16 inch.
Length Up to 20 feet, not inclusive. 20 feet to 30 feet, inclusive. Over 30 feet.	 Minus 0, Plus 1/4 inch. Minus 0, Plus 3/8 inch. Minus 0, Plus 1/2 inch.
Channels, depth.	Plus 3/32 inch, minus 1/16 inch.
Channels, width of flange.	Plus or minus 4 per cent of nominal width.
Weight of a lot or shipment of sizes 3 inches or larger.	Plus or minus 2½ per cent of nominal weight.[1]

[1]Actual weight shipped is invoiced. For sizes smaller than 3 inches, dimension tolerances only apply.

TABLE 45—COMMERCIAL TOLERANCES FOR THICKNESS OF FLAT 4S, ALCLAD 14S, 24S, ALCLAD 24S, 52S, 61S, SHEET AND PLATE

Applies only to commercial sizes,[1] tolerances for other sizes subject to inquiry.

Tolerance, Plus or Minus, Inch

Thickness, Inches	Width, Inches											
	Up to 18, incl.	Over 18 thru 36	Over 36 thru 48	Over 48 thru 54	Over 54 thru 60	Over 60 thru 66	Over 66 thru 72	Over 72 thru 78	Over 78 thru 84	Over 84 thru 90	Over 90 thru 96	Over 96 thru 120
0.046 to 0.068	0.0025	0.003	0.004	0.005	0.006	0.006	0.007	0.008	0.009	.....	.....	.....
0.069 to 0.076	0.003	0.003	0.004	0.005	0.006	0.008	0.010	0.010	0.011	0.012	.....	.....
0.077 to 0.096	0.0035	0.0035	0.004	0.005	0.006	0.008	0.010	0.010	0.011	0.012	.....	.....
0.097 to 0.108	0.004	0.004	0.005	0.005	0.007	0.010	0.012	0.013	0.014	0.016	0.018	0.020
0.109 to 0.140	0.0045	0.0045	0.005	0.005	0.007	0.010	0.012	0.013	0.014	0.016	0.018	0.020
0.141 to 0.172	0.006	0.006	0.008	0.008	0.009	0.012	0.014	0.015	0.016	0.017	0.019	0.023
0.173 to 0.203	0.007	0.007	0.010	0.010	0.011	0.014	0.016	0.017	0.017	0.017	0.022	0.026
0.204 to 0.249	0.009	0.009	0.011	0.011	0.013	0.016	0.018	0.018	0.018	0.018	0.024	0.028
0.250 to 0.320	0.013	0.013	0.013	0.013	0.015	0.018	0.020	0.020	0.020	0.020	.....	.....
0.321 to 0.438	0.019	0.019	0.019	0.019	0.020	0.020	0.023	0.023	0.025	0.025	0.026	.....
0.439 to 0.625	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.030	0.030	0.030	0.035	0.035
0.626 to 0.875	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.037	0.037	0.037	0.045	0.045
0.876 to 1.125	0.035	0.035	0.035	0.035	0.035	0.035	0.035	0.045	0.045	0.045	0.055	0.055
1.126 to 1.375	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.052	0.052	0.052	0.065	0.065
1.376 to 1.625	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.060	0.060	0.060	0.075	0.075
1.626 to 1.875	0.052	0.052	0.052	0.052	0.052	0.052	0.052	0.070	0.070	0.070	0.088	0.088
1.876 to 2.250	0.060	0.060	0.060	0.060	0.060	0.060	0.060	0.080	0.080	0.080	0.100	0.100
2.251 to 2.750	0.075	0.075	0.075	0.075	0.075	0.075	0.075	0.100	0.100	0.100	.....	.....
2.751 to 3.000	0.090	0.090	0.090	0.090	0.090	0.090	0.090	0.120	0.120	.....	.....	.....

[1]See Tables 75 and 76 for commercial sizes of sheet, and Tables 70 through 73 for commercial sizes of plate.

TABLE 46—COMMERCIAL TOLERANCES FOR COLD-FINISHED WIRE, ROD AND BAR, ALL ALLOYS

(Rounds, Squares, Hexagons, Rectangles up to 1½ Inches Thick or to 4 Inches Wide)

Diameter or Distance Across Flats, Inches	Tolerance, Inch, Plus or Minus		
	Rounds	Squares, Hexagons	Rectangles
Up to 0.035	0.0005	.....	0.001
0.036 to 0.064	0.001	.....	0.0015
0.065 to 0.500	0.0015	0.002	0.002
0.501 to 1.000	0.002	0.0025	0.0025
1.001 to 1.500	0.0025	0.003	0.003
1.501 to 2.000	0.004	0.005	0.005
2.001 to 3.000	0.004	.....	0.005
3.001 to 4.000	.....	.....	0.005

TABLE 47—COMMERCIAL TOLERANCES FOR ROLLED ROUND ROD, ALL ALLOYS

Diameter, Inches	Tolerance, Inch		Diameter, Inches	Tolerance, Inch	
	Plus	Minus		Plus	Minus
1.501 to 2.000	0.006	0.006	3.500 to 5.000	1/32	1/64
2.001 to 3.499	0.008	0.008	5.001 to 8.000	1/16	1/32

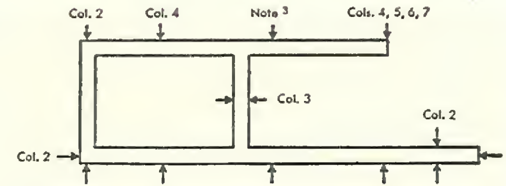
TABLE 48—COMMERCIAL TOLERANCES FOR ROLLED BAR, ALL ALLOYS

(Squares, Hexagons,[1] Rectangles)

Least Distance Across Flats, Inches	Tolerance, Inch, Plus or Minus	Width (of Rectangles), Inches	Tolerance, Inch, Plus or Minus
Up to 0.500	0.006	Up to 1.500	1/64
0.501 to 0.750	0.008	1.501 to 4.000	1/32
0.751 to 1.000	0.012	4.001 to 6.000	3/64
1.001 to 2.000	0.016	6.001 to 10.000	1/16
2.001 to 4.000	0.020		

[1]Available only in sizes greater than 1.5 inches; smaller sizes cold-finished.

TABLE 49—COMMERCIAL TOLERANCES FOR CROSS-SECTIONAL DIMENSIONS OF EXTRUDED RODS, BARS AND SHAPES



Specified dimension, inches	Tolerance,[1,2] inch, plus or minus					
	Metal dimensions		Space dimensions			
	Allowable deviation from specified dimension where 75% or more of the dimension is metal		Allowable deviation from specified dimension where more than 25% of the dimension is space[3,4] — At dimensioned points (Distance from base of leg)			
	All excepting those covered by column 3	Wall thickness[5] completely enclosing space 0.11 sq. in. and over (Eccentricity)	¼ inch to (not incl.) ⅝ inch	⅝ inch to (not incl.) 1¼ inches	1¼ inches to (not incl.) 2½ inches	2½ inches or more
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7
14.000 to 14.999	.080	Plus or minus 10% max. ±.060 min. ±.010	.090	.106	.142	.196
12.000 to 13.999	.074		.084	.100	.134	.184
10.000 to 11.999	.064		.074	.088	.116	.160
8.000 to 9.999	.054		.064	.074	.100	.136
6.000 to 7.999	.044		.054	.062	.082	.112
4.000 to 5.999	.034		.042	.050	.064	.088
2.000 to 3.999	.024		.032	.036	.048	.064
1.500 to 1.999	.016		.024	.028	.034	.050
1.000 to 1.499	.012		.020	.022	.026	.034
0.750 to 0.999	.010		.018	.020	.022	.030
0.500 to 0.749	.009		.016	.018	.020	.026
0.250 to 0.499	.008		.014	.016	.018	.022
0.125 to 0.249	.007		.012	.014	.016	.020
Under 0.125	.006		.010	.012	.014	.016

[1] The tolerance applicable to a dimension composed of two or more component dimensions is the sum of the tolerances of the component dimensions, if all of the component dimensions are indicated.

[2] When a dimension tolerance is specified other than as an equal bilateral tolerance, the value of the standard tolerance is that which would apply to the mean of the maximum and minimum dimensions permissible under the tolerance.

[3] At points less than ¼ inch from base of leg, the tolerances in Col. 2 are applicable.

[4] Where the space is completely enclosed (hollow shapes), the tolerances in Col. 4 are applicable.

[5] Where the dimensions specified are outside and inside, rather than the wall thickness itself, allowable deviation is plus or minus 10 per cent of **mean** wall thickness, max. ±0.060, min. ±0.010.

TABLE 50—COMMERCIAL TOLERANCES FOR ANGLES IN EXTRUDED SHAPES

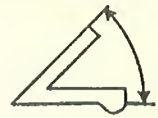
Minimum Specified Leg Thickness, Inch	Tolerance, Degrees, Plus or Minus
	 Allowable Deviation from Specified Angle
0.750 to solid	±1
0.188 to (not incl.) 0.750	±1½
Under 0.188	±2

TABLE 51—COMMERCIAL TOLERANCES FOR CONFORMANCE OF FLAT AND CURVED SURFACES OF EXTRUDED SHAPES

Curved Surfaces

Allowable deviation from specified contour, 0.004 inch per inch of chord length, 0.005 inch minimum; not applicable to more than 90 degrees of any arc.

Flat Surfaces

Allowable deviation from flat, 0.004 inch per inch of width; 0.004 inch minimum.

TABLE 52—COMMERCIAL TOLERANCES FOR STRAIGHTNESS OF EXTRUDED RODS, BARS AND SHAPES

Circumscribed Circle Diameter,[1] Inches	Minimum Thickness, Inch	Tolerance,[2] Inch — Allowable Deviation from Straight Per Foot of Length
1.50 and over	....	0.0125
Less than 1.50	Over 0.094	0.0125
Less than 1.50	0.094 or under	0.050(3)

[1]The circumscribed circle diameter is the diameter of the smallest circle that will completely enclose the shape.
[2]Not applicable to extruded shapes in the annealed (O) temper.
[3]When weight of shape on flat surface minimizes deviation.

TABLE 53—COMMERCIAL TOLERANCES FOR TWIST IN EXTRUDED BARS AND SHAPES

Circumscribed Circle Diameter,[1] Inches	Tolerance,[2] Degrees	
	Allowable Deviation from Straight	
	In Each Foot of Length	In Total Length of Piece
3.00 and over	¼°	Length, ft., times ¼° (not over 3°)
1.50 to 2.99	½°	Length, ft., times ½° (not over 5°)
Less than 1.50	1°	Length, ft., times 1°

[1]The circumscribed circle diameter is the diameter of the smallest circle that will completely enclose the shape.
[2]Not applicable to extruded shapes in the annealed (O) temper.

TABLE 54—COMMERCIAL TOLERANCES FOR CORNER AND FILLET RADII OF EXTRUDED SHAPES

Specified Radius, Inch	Tolerance
	Allowable Deviation from Specified Radius
0.188 and over	±10%
Under 0.188	±1/64 inch
Sharp corners	+1/64 inch

TABLE 55—COMMERCIAL TOLERANCES FOR LENGTH OF EXTRUDED RODS, BARS AND SHAPES[1]

Specified Length, Feet	Tolerance, Inch, Plus Only
	Allowable Deviation from Specified Length
30 and over	1/2
10 to (not incl.) 30	1/4
Less than 10	1/8

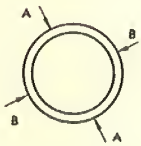
[1]Squareness of cut ends—1 degree.

TABLE 56—STANDARD TOLERANCES[1] FOR DRAWN TUBING

ROUND

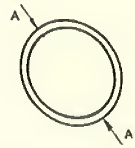
Diameter Tolerances

SIZE DEVIATION



Difference between $\frac{AA+BB}{2}$ and specified diameter. Col. 2

ROUNDNESS DEVIATION (OVALNESS)



Difference between AA and specified diameter. Cols. 3 and 4

Specified outside or inside diameter, inches	Tolerance, inch		
	Allowable deviation of mean diameter[2] from specified diameter (*Size*)	Allowable deviation of diameter at any point from specified diameter[3] (*Ovalness*)	
		3S, 4S, 52S	24S, 61S
Col. 1	Col. 2	Col. 3	Col. 4
Under .501	±.003	±.003	±.006
.501 to 1.00	±.004	±.004	±.008
1.01 to 2.00	±.005	±.005	±.010
2.01 to 3.00	±.006	±.006	±.012
3.01 to 5.00	±.008	±.008	±.016
5.01 to 6.00	±.010	±.010	±.020
6.01 to 8.00	±.015	±.015	±.030
8.01 to 10.00	±.020	±.020	±.040
10.01 and over	±.025	±.025	±.050

[1]Tolerances closer than these or tolerances for special other than round tubular shapes should be made the subject of special inquiry.

[2]The "mean diameter" is the average of two measurements taken at right angles to each other.

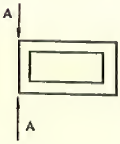
[3]Not applicable in the annealed (O) temper nor if wall thickness is less than 2½ per cent of the outside diameter, or is less than 0.020 inch.

TABLE 57—STANDARD TOLERANCES[1] FOR DRAWN TUBING[2]

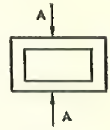
OTHER THAN ROUND

Width or Depth Tolerances

SIZE DEVIATION



Difference between AA and specified width or depth. Col. 2



Difference between AA and specified width or depth. Col. 4

Specified width or depth, inches	Tolerance, inch		
	Allowable deviation of width or depth at corners from specified width or depth	Allowable deviation of width or depth not at corners from specified width or depth	
		Square, hexagonal and octagonal	Rectangular
Col. 1	Col. 2	Col. 3	Col. 4
Under .501	±.003	±.006	The tolerance for the width is the value in Col. 3 for a dimension equal to the depth, and conversely, but in no case is the tolerance less than at the corners.[3]
.501 to 1.00	±.004	±.008	
1.01 to 2.00	±.005	±.010	
2.01 to 3.00	±.006	±.012	
3.01 to 5.00	±.008	±.016	
5.01 to 6.00	±.010	±.020	
6.01 to 8.00	±.015	±.030	
8.01 to 10.00	±.020	±.040	
10.01 and over	±.025	±.050	

[1]Tolerances closer than these or tolerances for special other than round tubular shapes should be made the subject of special inquiry.

[2]Heat-treated tubing produced with tools constructed for nonheat-treated tubing will be .003 inch to .010 inch undersize. Nonheat-treated tubing produced with tools constructed for heat-treated tubing will be .003 inch to .010 inch oversize.

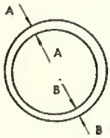
[3]Example: The width tolerance of 1-inch x 3-inch rectangular tubing is plus or minus .008 inch and the depth tolerance is plus or minus .012 inch.

TABLE 58—STANDARD TOLERANCES[1] FOR DRAWN TUBING

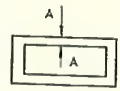
ROUND AND OTHER THAN ROUND

Wall Thickness Tolerances

WALL THICKNESS DEVIATION

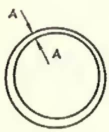


Difference between $\frac{AA+BB}{2}$ and specified wall thickness. Col. 2

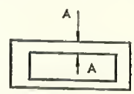


Difference between AA and specified wall thickness. Col. 4

CONCENTRICITY DEVIATION (ECCENTRICITY)



Difference between AA and specified wall thickness. Cols. 3 and 4



Difference between AA and specified wall thickness. Col. 4

Specified[3] thickness, inch	Tolerance, inch		
	Allowable deviation of mean wall thickness[2] from specified wall thickness	Allowable deviation of wall thickness **at any point** from specified wall thickness (*Eccentricity*)	
	Round 24S, 61S	Round 3S, 4S, 52S	Round 24S, 61S and other than round all alloys
Col. 1	Col. 2	Col. 3	Col. 4
.010 to .035	±.002	±.002	Plus or minus 10% of specified wall thickness, but not less than 0.003″
.036 to .049	±.003	±.003	
.050 to .120	±.004	±.004	
.121 to .203	±.005	±.005	
.204 to .300	±.008	±.008	
.301 to .375	±.012	±.012	
.376 to .500	±.032	±.032	

[1]Tolerances closer than these or tolerances for special other than round tubular shapes should be made the subject of special inquiry.

[2]The "mean wall thickness" is the average of two measurements taken opposite each other.

[3]Where the dimensions specified are outside and inside, rather than the wall thickness itself, allowable deviation at any point (eccentricity) is plus or minus 10 per cent of mean wall thickness, but not less than 0.003 inch.

TABLE 59—STANDARD TOLERANCES[1] FOR DRAWN TUBING

Length Tolerances

Specified outside diameter, inches	Tolerance, inch — Allowable deviation from specified length					
	Straight				Coiled	
	Specified length, feet					
	Under 2	2 to (not incl.) 10	10 to (not incl.) 30	30 and over	50 and less	Over 50
Under ¼	+⅛	+¼	+⅜	+½	+12	+24
¼ to (not incl.) 3	+1/16	+⅛	+3/16	+¼	+12	+24
3 to (not incl.) 8	+3/16	+3/16	+¼	+⅜	....	....
8 and over	+¼	+¼	+⅜	....	....	....

[1]Tolerances closer than these should be made the subject of special inquiry.

TABLE 60—OTHER STANDARD TOLERANCES[1] FOR DRAWN TUBING

Corner Radii Tolerances

Specified radius, inches	Tolerance, inch — Allowable deviation from specified radius
Sharp corners	+1/64
Under 0.188	±1/64
0.188 and over	±10%

Twist Tolerances

Specified width or depth, (whichever greater) inches	Tolerance[2], degrees — Allowable deviation from straight	
	In each foot of length	In total length of piece
Under 1½	1°	Length, ft., times 1°
1½ to (not incl.) 3	½°	Length, ft., times ½°, not over 5°
3 and over	¼°	Length, ft., times ¼°, not over 3°

[1]Tolerances closer than these should be made the subject of special inquiry.
[2]Not applicable in the annealed (O) temper.

TABLE 60—OTHER STANDARD TOLERANCES[1] FOR DRAWN TUBING—Concluded

Straightness Tolerances

Specified outside diameter or width, inches	Tolerance[2], inch Allowable deviation from straight per foot of length
Under ⅜	.500[3]
⅜ to (not incl.) 6	.010
6 and over	.020

Angularity Tolerance

± 3 degrees.

Tolerance on Squareness of Cut Ends

1 degree.

Shipping Tolerances

Specified pounds per order item	Tolerance, per cent
Under 500	±10
500 to (not incl.) 10,000	± 5
10,000 and over	± 3

[1]Tolerances closer than these should be made the subject of special inquiry.

[2]Not applicable in the annealed (O) temper.

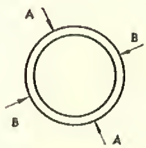
[3]Deviation becomes less when tube is laid on a flat surface. Not applicable to lengths under 10 feet.

TABLE 61—STANDARD TOLERANCES[1] FOR EXTRUDED TUBING

ROUND

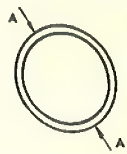
Diameter Tolerances

SIZE DEVIATION



Difference between $\frac{AA+BB}{2}$ and specified diameter. Col. 2

ROUNDNESS DEVIATION (OVALNESS)



Difference between AA and specified diameter. Col. 3

Specified outside or inside diameter, inches Col. 1	Tolerance, inch Allowable deviation of mean diameter[2] from specified diameter (*Size*) Col. 2	Tolerance, inch Allowable deviation of diameter at any point from specified diameter[3] (*Ovalness*) Col. 3
½ to (not incl.) 1	±.010	±.020
1 to (not incl.) 2	±.012	±.025
2 to (not incl.) 4	±.015	±.030
4 to (not incl.) 6	±.025	±.050
6 to (not incl.) 8	±.035	±.075
8 to (not incl.) 10	±.045	±.100
10 to (not incl.) 12	±.055	±.125
12 to (incl.) 12¼	±.065	±.150

[1]Tolerances closer than these should be made the subject of special inquiry.

[2]The "mean diameter" is the average of two measurements taken at right angles to each other.

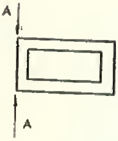
[3]Not applicable in the annealed (O) temper or if wall thickness is less than 2½ per cent of the outside diameter.

TABLE 62—STANDARD TOLERANCES[1] FOR EXTRUDED TUBING

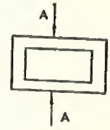
OTHER THAN ROUND

Width or Depth Tolerances

SIZE DEVIATION



Difference between AA and specified width or depth. Col. 2



Difference between AA and specified width or depth. Col. 4

Specified width or depth, inches	Tolerance, inch		
	Allowable deviation of width or depth at corners from specified width or depth	Allowable deviation of width or depth not at corners from specified width or depth	
		Square, hexagonal and octagonal	Rectangular
Col. 1	Col. 2	Col. 3	Col. 4
½ to (not incl.) ¾	±.012	±.020	The tolerance for the width is the value in Col. 3 for a dimension equal to the depth, and conversely, but in no case is the tolerance less than at the corners.[2]
¾ to (not incl.) 1	±.014	±.020	
1 to (not incl.) 2	±.018	±.025	
2 to (not incl.) 4	±.025	±.035	
4 to (incl.) 5	±.035	±.045	

[1] Tolerances closer than these should be made the subject of special inquiry.

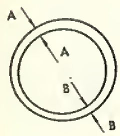
[2] Example: The width tolerance of 1-inch x 3-inch rectangular tubing is plus or minus .025 inch and the depth tolerance is plus or minus .035 inch.

TABLE 63—STANDARD TOLERANCES[1] FOR EXTRUDED TUBING

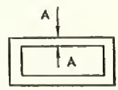
ROUND AND OTHER THAN ROUND

Wall Thickness Tolerances

WALL THICKNESS DEVIATION

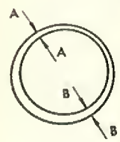


Difference between $\frac{AA+BB}{2}$ and specified wall thickness. Cols. 2, 3, 4

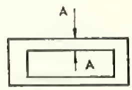


Difference between AA and specified wall thickness. Col. 6

CONCENTRICITY DEVIATION (ECCENTRICITY)



Difference between AA and $\frac{AA+BB}{2}$ Col. 5



Difference between AA and specified wall thickness. Col. 6

Specified thickness,† inches	ROUND				OTHER THAN ROUND
	Tolerance, inch[2]				
	Allowable deviation of mean wall thickness[3] from specified wall thickness			Allowable deviation of wall thickness at any point from mean wall thickness[3] (*Eccentricity*)	Allowable deviation of wall thickness at any point from specified wall thickness
	Outside diameter, inches				
	Under 3	3 to (not incl.) 5	5 and over		
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6
Under .063..	±.007	±.008	±.010	Plus or minus 10% of mean wall thickness; max. ±0.060 min. ±0.010	Plus or minus 10% of mean wall thickness; max. ±0.060 min. ±0.010
.063 to (not incl.) .125..	±.008	±.010	±.015		
.125 to (not incl.) .250.	±.009	±.013	±.020		
.250 to (not incl.) .375..	±.011	±.016	±.025		
.375 to (not incl.) .500..	±.015	±.021	±.035		
.500 to (not incl.) .750..	±.020	±.028	±.045		
.750 to (not incl.) 1.0 ..	....	±.035	±.055		
1.0 to (not incl.) 1.5 ..	....	±.045	±.065		

[1]Tolerances closer than these should be made the subject of special inquiry.

[2]If the extruded tubing is to be drawn into drawn tubing, allowance for tolerances greater than standard is recommended.

[3]The "mean wall thickness" is the average of two measurements taken opposite each other.

[4]Example: The width tolerance of 1-inch x 3-inch rectangular tubing is plus or minus .025 inch and the depth tolerance is plus or minus .035 inch.

†Where dimensions specified are outside and inside rather than wall thickness itself, allowable deviation at any point (eccentricity) is plus or minus 10 per cent of the mean wall thickness, but not less than 0.003 inch.

TABLE 64—STANDARD TOLERANCES[1] FOR EXTRUDED TUBING

Length Tolerances

Specified outside diameter, inches	Tolerance, inch — Allowable deviation from specified length — Specified length, feet		
	Under 10	10 to (not incl.) 30	30 and over
Under 3	+1/8	+3/16	+1/4
3 to (not incl.) 8	+3/16	+1/4	+3/8
8 and over	+1/4	+3/8	+1/2

[1]Tolerances closer than these should be made the subject of special inquiry.

TABLE 65—OTHER STANDARD TOLERANCES[1] FOR EXTRUDED TUBING

Corner Radii Tolerances

Specified radius, inches	Tolerance, inch — Allowable deviation from specified radius
Sharp corners	+1/64
Under 0.188	±1/64
0.188 and over	±10%

Twist Tolerances

Specified width, inches	Tolerance[2], degrees — Allowable deviation from straight	
	In each foot of length	In total length of piece
Under 1½	1°	Length, ft., times 1°
1½ to (not incl.) 3	½°	Length, ft., times ½°, not over 5°
3 and over	¼°	Length, ft., times ¼°, not over 3°

[1]Tolerances closer than these should be made the subject of special inquiry.
[2]Not applicable in the annealed (O) temper.

TABLE 65—OTHER STANDARD TOLERANCES[1] FOR EXTRUDED TUBING—Concluded

Straightness Tolerances

Specified outside diameter or width, inches	Tolerance[2], inch
	Allowable deviation from straight per foot of length
Under 6	.010
6 and over	.020

Angularity Tolerance

± 3 degrees.

Tolerance on Squareness of Cut Ends

1 degree.

Shipping Tolerances

Specified pounds per order item	Tolerance, per cent
Under 500	±10
500 to (not incl.) 10,000	± 5
10,000 and over	± 3

[1]Tolerances closer than these should be made the subject of special inquiry.
[2]Not applicable in the annealed (O) temper.

TABLE 66—FLAT SHEET—ALCOA MILL STANDARD SIZES

Thickness, Inch	3S-O	3S-H14	52S-O	52S-H32	52S-H34
0.051	.... 36 x 96 48 x 144	.... 36 x 96 48 x 144	.... 36 x 96 48 x 144	.... 36 x 96 48 x 144	.... 48 x 144
0.064	.... 36 x 96 48 x 144	.... 36 x 96 48 x 144	.... 36 x 96 48 x 144	.... 36 x 96 48 x 144	.... 48 x 144
0.081	36 x 96 48 x 144	36 x 96 48 x 144	.... 48 x 144	36 x 96 48 x 144	.... 48 x 144
0.091	36 x 96 48 x 144	36 x 96 48 x 144	.... 48 x 144	36 x 96 48 x 144	.... 48 x 144
0.125	36 x 96 48 x 144	36 x 96 48 x 144	.... 48 x 144	36 x 96 48 x 144	.... 48 x 144
0.188	....	36 x 96 48 x 144	.... 48 x 144	36 x 96 48 x 144	.... 48 x 144
0.250	....	36 x 96(1) 48 x 144(1)	....	....	.... 48 x 144(1)

[1]F temper ("As-rolled").

TABLE 67—FLAT SHEET AND PLATE—ALCOA MILL STANDARD SIZES

Thickness, Inch	61S-O, -T4 and -T6	24S-O, -T3 and -T4	Alclad 24S-O, -T3 and -T4
0.051	48 x 144	48 x 144	48 x 144
0.064	48 x 144	48 x 144	48 x 144
0.072	....	48 x 144	48 x 144
0.081	48 x 144	48 x 144	48 x 144
0.091	48 x 144	48 x 144	48 x 144
0.102	....	48 x 144	48 x 144
0.125	48 x 144	48 x 144	48 x 144
0.156	....	48 x 144	48 x 144
0.188	48 x 144(1)	48 x 144	48 x 144
0.250	48 x 144(1)	48 x 144	48 x 144

[1]Not available in T4 temper.

TABLE 68—COMMERCIAL SIZES OF ALCOA TREAD PLATE (61S)

Standard Pattern C-100

Thickness, Inch	Standard Sizes, Inches	Maximum Rolling Limits[1]		Approximate Weight, Lb./Sq. Ft.
		Width, Inches	Length, Feet	
1/8	48 x 144	48	24	2.0
3/16	48 x 144	60	24	2.8
	60 x 144	60	24	2.8
1/4	48 x 144	60	24	3.7
	60 x 144	60	24	3.7
5/16	....	60	24	4.6
3/8	....	60	24	5.5
	....	60	24	5.5
1/2	....	60	24	7.3
	....	60	24	7.3

[1]Non-standard sizes and tempers are subject to special inquiry as to next rolling date.

TABLE 69—RANGE OF COMMERCIAL SIZES OF WIRE, ROD AND BAR[1]

All Alloys

Commodity	Smallest	Largest
	Diameter, Inches	Diameter, Inches
Round Wire—Drawn	0.0126	0.374
Round Rod—Cold-Finished	3/8	3
Round Rod—Rolled	1 9/16	8
	Distance Across Flats, Inches	Distance Across Flats, Inches
Square Wire—Drawn	1/8 x 1/8	11/32 x 11/32
Square Bar—Cold-Finished	3/8 x 3/8	1 1/2 x 1 1/2
Square Bar—Rolled	1 5/8 x 1 5/8	4 x 4
Hexagonal Wire—Drawn	3/16	11/32
Hexagonal Bar—Cold-Finished	3/8	2
Hexagonal Bar—Rolled	1 9/16	3
	Dimensions, Inch	Dimensions, Inches
Square Edge Rectangular Wire—Drawn	1/32 x 1/8	5/16 x 11/32
Square Edge Rectangular Bar—Cold-Finished	1/8 x 1/2	1 1/2 x 4
Square Edge Rectangular Bar—Rolled	3/16 x 3/4	3 x 7
Round Edge Rectangular Bar—Rolled	3/16 x 3/4	1/2 x 6

[1]This table indicates the range of commercial sizes. All alloys are not produced in all of the sizes listed; consult the sales representative of Aluminum Company of America for details.

TABLE 70—MAXIMUM COMMERCIAL[1] SIZES OF PLATE[2]
ALLOY 3S
Mill Finish Only

Thickness, Inches	Maximum Width, Inches	Maximum Length for Maximum Width, Feet	Maximum Length (Feet) for Indicated Widths							
			Widths 40″ or less	Width 60″	Width 72″	Width 84″	Width 96″	Width 108″	Width 120″	Width 132″
3	92	7.6	17.7	11.8	9.9	8.4	....	....	....	....
2¾	96	8.0	19.3	12.8	10.6	9.1	8.0	....	....	....
2½	101	8.4	21.2	14.2	11.7	10.0	8.7	....	....	....
2¼	106	8.8	22.8	15.2	12.6	10.8	9.5	....	....	....
2	113	9.4	26.5	17.6	14.6	12.5	10.8	9.7	....	....
1¾	120	10.0	30.3	20.1	16.7	14.3	12.5	11.1	10.0	....
1½	130	10.8	35.4	23.6	19.6	16.8	14.7	13.0	11.7	....
1¼	132	12.9	42.5	28.3	23.6	20.2	17.6	15.6	14.0	12.9
1	132	16.2	53.1	35.4	28.5	24.4	21.3	18.9	17.0	16.2
⅞	132	18.5	60.8	40.5	33.7	28.8	25.2	22.4	20.1	18.5
¾	132	21.6	70.7	47.0	39.2	33.6	29.4	26.1	23.4	21.6
⅝	132	25.8	72.0	56.7	47.3	40.5	35.4	31.4	28.2	25.8
½	132	32.2	60.0	60.0	59.0	50.5	44.0	39.1	35.1	32.2
⅜	120	41.8	40.0	60.0	72.0	67.2	58.8	52.1	41.8	....
¼	102	48.0	36.0	50.0	60.0	60.0	60.0	....	....	....

[1]For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of the manufacturing equipment, and will be quoted on request.

[2]The dimensions shown are subject to the following limitations:

(a) The sizes shown apply to plate in the as-rolled (F) temper.

(b) The maximum limiting sizes of plate in any alloy in the soft (O) temper are:

Lengths to 36 feet for widths up to 100 inches.

Lengths to 30 feet for widths over 100 inches to maximum width of 118 inches.

(c) Maximum diameter of circle same as maximum width of plate except 118 inches is maximum diameter for annealed (O) temper circles.

(d) Plate can be supplied in the following tempers:

Thickness 3 inches to 2 inches—As-rolled (F), Soft (O).

Thickness less than 2 inches to 1 inch—
As-rolled (F), Soft (O), Quarter-Hard (H12).

Thickness less than 1 inch to ¼ inch—
As-rolled (F), Soft (O), Quarter-Hard (H12), Half-Hard (H14).

(e) Flatness. The degree of flatness which can be obtained depends on the alloy and temper, and upon the dimensions of the plate:

The limiting maximum size for stretcher-leveled plate is ⅞ inch thick by 90 inches wide in all commercial lengths.

Plate wider than 90 inches and/or thicker than ⅞ inch is supplied roller-leveled.

Plate thicker than 1 inch is supplied as flat as can be produced on the rolling mills.

(f) Shearing. Unless otherwise specified, plates in all commercial widths in thicknesses up to 1 inch are sheared. Minimum sheared widths are as follows:

Thickness	Minimum sheared width
0.250 inch to 0.375 inch	6 inches
0.376 inch to 1.000 inch	8 inches for lengths up to 10 feet. 18 inches for lengths greater than 10 feet.

Thicker plate or narrower widths must be sawed.

Plate circles are sheared, unless otherwise specified, as follows:

Thicknesses ¼ inch to ⅝ inch inclusive.

Diameters 17½ inches to 96 inches inclusive.

Thicker circles and larger diameters are sawed.

Method of cutting smaller diameters subject to special inquiry.

TABLE 71—MAXIMUM COMMERCIAL[1] SIZES OF PLATE[2]
ALLOYS 4S AND 52S

Mill Finish Only

Thickness, Inches	Maximum Width, Inches	Maximum Length for Maximum Width		Maximum Length (Feet) for Indicated Widths						
		Inches	Feet	Widths 43″ or less	Width 60″	Width 72″	Width 84″	Width 96″	Width 108″	Width 120″
3	82	82	6.8	12.9	9.1	7.6	....	....	....	....
2¾	85	85	7.1	14.0	10.0	8.3	....	....	....	....
2½	87	87	7.2	15.4	11.0	9.1	....	....	....	....
2¼	94	94	7.8	17.1	12.2	10.1	8.5	....	....	....
2	100	100	8.3	19.3	13.8	11.5	9.7	....	....	....
1¾	107	107	8.9	22.1	15.7	13.0	11.1	9.7	....	....
1½	116	116	9.7	25.8	18.3	15.2	12.8	11.4	10.2	....
1¼	120	130	10.8	30.9	22.0	18.3	15.6	13.6	12.0	10.8
1	120	166	13.8	38.6	27.6	23.0	19.7	17.2	15.2	13.8
⅞	120	190	15.8	44.1	31.5	26.2	22.4	19.6	17.4	15.8
¾	120	222	18.5	51.5	36.8	30.6	26.2	22.8	20.2	18.5
⅝	120	266	22.2	60.0	44.2	36.8	30.5	26.6	23.6	22.2
½	120	332	27.7	60.0	55.0	45.7	39.0	34.0	30.2	27.7
⅜	96	555	46.2	40.0	50.0	61.3	52.5	46.2	....	....
¼	90	600	50.0	36.0	40.0	50.0	50.0	....	....	....

[1]For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of the manufacturing equipment, and will be quoted on request.

[2]The dimensions shown are subject to the following limitations:

(a) The sizes shown apply to plate in the as-rolled (F) temper.

(b) In the quarter-hard (H32) and half-hard (H34) tempers, the maximum limiting lengths are:

30 feet for widths up to 100 inches.

24 feet for widths greater than 100 inches to maximum width shown in the table.

(c) The maximum limiting sizes of plate in any alloy in the soft (O) temper are:

Lengths to 36 feet for widths up to 100 inches.

Lengths to 30 feet for widths over 100 inches to maximum width of 118 inches.

(d) Maximum diameter of circle same as maximum width of plate except 118 inches is maximum diameter for annealed (O) temper circles:

(e) Plate can be supplied in the following tempers:

Thickness 3 inches to 2 inches—As-rolled (F), Soft (O).

Thickness less than 2 inches to 1 inch—
As-rolled (F), Soft (O), Quarter-Hard (H32).

Thickness less than 1 inch to 1/4 inch—
As-rolled (F), Soft (O), Quarter-Hard (H32), Half-Hard (H34).

(f) Flatness. The degree of flatness which can be obtained depends on the dimensions of the plate:

The limiting maximum size for stretcher-leveled plate is 7/8 inch thick by 90 inches wide in all commercial lengths.

Plate wider than 90 inches and/or thicker than 7/8 inch is supplied roller-leveled.

Plate thicker than 1 inch is supplied as flat as can be produced on the rolling mills.

(g) Shearing. Unless otherwise specified, plates in all commercial widths in thicknesses up to 5/8 inch are sheared. Minimum sheared widths are as follows:

Thickness	Minimum sheared width
0.250 inch to 0.375 inch	6 inches
0.376 inch to 0.625 inch	8 inches for lengths up to 10 feet. 18 inches for lengths greater than 10 feet.

Thicker plate or narrower widths must be sawed—except that rough sheared plate 0.626 inch to 1 inch thick, 24 inches or over in width and 72 inches to 120 inches long can be supplied if so specified. The length and width tolerances for rough sheared plate are +1 inch, −0 inch.

Plate circles are sheared, unless otherwise specified, as follows:

Thicknesses 1/4 inch to 5/8 inch inclusive.

Diameters 17½ inches to 96 inches inclusive.

Thicker circles and larger diameters are sawed.

Method of cutting smaller diameters subject to special inquiry.

TABLE 72—MAXIMUM COMMERCIAL[1] SIZES OF HEAT-TREATABLE ALLOY PLATE[2]

ALLOYS 24S ALCLAD 24S AND 61S

Mill Finish Only

Alloys	Thickness, Inches	Maximum Width, Inches	Maximum Length for Maximum Width		Maximum Length (Feet) for Indicated Widths				
			Inches	Feet	Widths 43″ or less	Width 60″	Width 72″	Width 84″	Width 96″
61S	3	60	60	5.0	7.1	5.0	....	....	....
61S	2¾	63	63	5.2	7.7	5.5	....	....	....
61S	2½	66	66	5.5	8.5	6.0	....	....	....
61S	2¼	70	70	5.8	9.5	6.8	....	....	....
24S, 61S	2	74	74	6.2	10.0	7.6	6.3	....	....
24S, 61S	1¾	79	79	6.6	10.0	8.7	7.3	....	....
24S, 61S	1½	86	86	7.1	10.0	10.0	8.4	7.2	....
24S, 61S	1¼	94	94	7.8	10.0	10.0	10.0	8.8	....
24S, 61S	1	105	105	8.7	10.0	10.0	10.0	10.0	9.5
61S	⅞	88	143	11.9	24.4	17.5	14.6	12.5	....
61S	¾	90	163	13.6	28.4	20.5	16.9	14.5	....
61S	⅝	90	196	16.3	34.1	24.4	20.5	17.4	....
61S	½	90	246	20.5	36.0	30.5	25.4	21.8	....
61S	⅜	84	348	29.0	36.0	36.0	33.9	29.0	....
61S	¼	72	360	30.0	30.0	30.0	30.0	....	....
24S	⅞	44	286	23.8	24.4	....	....	....	....
24S	¾	51	286	23.8	28.4	....	....	....	....
24S	⅝	62	286	23.8	34.1	24.4	....	....	....
24S, Alclad 24S	½	78	286	23.8	36.0	30.5	25.4	....	....
24S, Alclad 24S	⅜	84	348	29.0	36.0	36.0	33.9	29.0	....
24S, Alclad 24S	¼	72	360	30.0	30.0	30.0	30.0	....	....

[1]In some cases larger sizes can be produced by means of special manufacturing practices; requirements for larger sizes should be the subject of special inquiry. In many cases the maximum sizes listed are determined by available flattening equipment rather than rolling capacity, in which cases larger sizes may be produced in the soft (O) temper. These are not listed since these alloys are used almost exclusively in the heat-treated tempers. For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of manufacturing equipment, and will be quoted on request.

[2]The dimensions shown are subject to the following limitations:

(a) The maximum limit in length of plates in these alloys in the soft (O) temper is 30 feet.

(b) The maximum diameter of circles same as maximum width of plate.

(c) Flatness. The degree of flatness which can be obtained depends upon the alloy and temper, and upon the dimensions of the plate. The maximum degree of flatness in these alloys in the heat-treated tempers, in thicknesses over ½ inch, can be supplied in lengths up to 120 inches.

(d) Shearing. Unless otherwise specified, plates in all commercial widths in thicknesses up to the limits shown below are sheared. The minimum widths of sheared plate are as follows:

Thickness	Minimum sheared width
24S, 61S 0.250 inch to 0.375 inch	6 inches
61S 0.376 inch to 0.625 inch; 24S 0.376 inch to 0.500 inch	8 inches for lengths up to 10 feet. 18 inches for lengths greater than 10 feet.

Thicker plate or narrower widths must be sawed—except that rough sheared 61S plate 0.626 inch to 1 inch thick, and 24S plate 0.501 inch to 1 inch thick, can be supplied if so specified in widths of 24 inches and over and in lengths of 72 inches to 120 inches. The length and width tolerances for rough sheared plate are +1 inch, −0 inch.

Plate circles 17½ inches diameter and larger in ¼ inch thickness are sheared, unless otherwise specified. The following sizes are sawed:

Diameters 7½ inches to 17½ inches, thickness ¼ inch.

Diameters 7½ inches and larger, over ¼ inch thickness.

Diameters smaller than 7½ inches quoted specially.

TABLE 73—MAXIMUM COMMERCIAL[1] SIZES OF HEAT-TREATABLE ALLOY PLATES[2]

ALCLAD 14S ALLOY

Mill Finish Only

Alloys	Thickness, Inches	Maximum Width, Inches	Maximum Length for Maximum Width		Maximum Length (Feet) for Indicated Widths				
			Inches	Feet	Widths 43″ or less	Width 60″	Width 72″	Width 84″	Width 96″
Alclad 14S	2	74	74	6.2	10.0	7.6	6.3	....	....
	1¾	79	79	6.6	10.0	8.7	7.3	....	....
	1½	86	86	7.1	10.0	10.0	8.4	7.2	....
	1¼	94	94	7.8	10.0	10.0	10.0	8.8	....
	1	105	105	8.7	10.0	10.0	10.0	10.0	9.5
Alclad 14S	⅞	40	288	24.0	24.0	....	....	....	....
	¾	47	288	24.0	29.0	....	....	....	....
	⅝	57	288	24.0	34.0	....	....	....	....
	½	72	288	24.0	36.0	29.0	24.0	....	....
	⅜	84	348	29.0	36.0	36.0	33.9	29.0	....
	¼	72	360	30.0	30.0	30.0	30.0	....	....

[1]In some cases larger sizes can be produced by means of special manufacturing practices; requirements for larger sizes should be the subject of special inquiry. In many cases the maximum sizes listed are determined by available flattening equipment rather than rolling capacity, in which cases larger sizes may be produced in the soft (O) temper. These are not listed since this alloy is used almost exclusively in the heat-treated tempers. For thicknesses or lengths intermediate between those listed, available dimensions are in proportion within the limits of manufacturing equipment, and will be quoted on request.

[2]The dimensions shown are subject to the following limitations:

(a) The maximum limit in length of plates in these alloys in the soft (O) temper is 30 feet.

(b) Maximum diameter of circles same as maximum width of plate.

(c) Flatness. The degree of flatness which can be obtained depends upon the alloy and temper, and upon the dimensions of the plate. The maximum degree of flatness in this alloy in the heat-treated tempers, in thicknesses over ½ inch, can be supplied in lengths up to 120 inches.

(d) Shearing. Unless otherwise specified, plates in all commercial widths of 6 inches or greater and in thickness up to 0.375 inch, inclusive, are sheared. Thicker plates or narrower widths must be sawed.

Plate circles 17½ inches diameter and larger in ¼ inch thickness are sheared, unless otherwise specified. The following sizes are sawed:

Diameters 7½ inches to 17½ inches, thickness ¼ inch.

Diameters 7½ inches and larger, over ¼ inch thickness.

Diameters smaller than 7½ inches quoted specially.

TABLE 74—RANGE OF COMMERCIAL SIZES OF ROUND TUBING[1, 4]

Outside diameter,[2] inches	Minimum wall thickness, inch			Maximum wall thickness, inch — Where tubing is specified by outside diameter and wall thickness										Specified by O.D. & I.D. or I.D. & wall
	2S 3S 61S	4S 52S	24S	2S-O 3S-O 61S-O	2S-F 3S-F	2S-H12 3S-H12	2S-H14 3S-H14	2S-H16 3S-H16	2S-H18 3S-H18	4S 52S	61S-F	61S-T4 61S-T6	24S-F 24S-T3	All alloys
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15
1/8	.014	.018	.018	.049	.049	.049	.049	.049	.049	.049	.049	.049	.049	....
3/16	.014	.018	.018	.083	.078	.078	.078	.078	.078	.078	.078	.078	.078	.028
1/4	.014	.018	.018	.120	.109	.109	.109	.109	.109	.109	.109	.109	.109	.058
5/16	.014	.018	.018	.134	.134	.134	.134	.134	.134	.120	.134	.134	.120	.083
3/8	.016	.018	.018	.148	.148	.148	.148	.148	.148	.134	.148	.148	.134	.120
7/16	.018	.018	.020	.165	.165	.165	.165	.165	.165	.148	.165	.165	.148	.148
1/2	.018	.020	.020	.180	.180	.180	.180	.180	.180	.165	.180	.180	.165	.148
5/8	.018	.020	.020	.238	.238	.238	.238	.238	.238	.180	.238	.238	.180	.203[3]
3/4	.018	.020	.022	.259	.259	.259	.259	.259	.259	.203	.259	.259	.203	.238[3]
7/8	.018	.020	.022	.300	.300	.300	.300	.300	.300	.220	.300	.300	.220	.284[3]
1	.020	.022	.025	.320	.320	.320	.320	.320	.320	.238	.320	.320	.238	.284[3]
1 1/8	.020	.022	.025	.320	.320	.320	.320	.320	.320	.259	.320	.320	.259	.320[3]
1 1/4	.020	.022	.025	.320	.320	.320	.320	.320	.320	.284	.320	.320	.284	.320[3]
1 3/8	.020	.022	.025	.375	.375	.375	.375	.375	.375	.300	.375	.375	.300	.375[3]
1 1/2	.020	.022	.028	.450	.450	.450	.450	.450	.450	.300	.450	.450	.300	.400[3]
1 5/8	.020	.022	.028	.450	.450	.450	.450	.450	.450	.320	.450	.450	.320	.400[3]
1 3/4	.020	.022	.028	.450	.450	.450	.450	.450	.450	.320	.450	.450	.320	.400[3]
1 7/8	.020	.022	.028	.450	.450	.450	.450	.450	.450	.350	.450	.450	.350	.400[3]
2	.022	.028	.032	.450	.450	.450	.450	.450	.450	.350	.450	.450	.350	.400[3]
2 1/4	.022	.028	.032	.450	.450	.450	.450	.450	.450	.400	.450	.450	.400	.400
2 1/2	.022	.028	.035	.450	.450	.450	.450	.450	.450	.400	.450	.450	.400	.400
2 3/4	.022	.028	.035	.500	.500	.500	.500	.500	.500	.450	.500	.500	.450	.400
3	.028	.035	.042	.500	.500	.500	.500	.500	.500	.450	.500	.500	.450	.400
4	.042	.049	.049	.500	.500	.500	.500	.500	.480	.450	.500	.500	.450	.400
4 1/4	.042	.049	.049	.500	.500	.500	.500	.500	.450	.450	.500	.500	.450	.400
4 1/2	.042	.049	.049	.500	.500	.500	.500	.500	.400	.400	.500	.500	.450	.400
4 3/4	.042	.049	.049	.500	.500	.500	.500	.500	.375	.375	.500	.500	.450	.400[3]

TABLE 74—RANGE OF COMMERCIAL SIZES OF ROUND TUBING[1, 4]—Concluded

Outside diameter,[2] inches	Minimum wall thickness, inch			Maximum wall thickness, inch										
				Where tubing is specified by outside diameter and wall thickness										Specified by O.D. & I.D. or I.D. & wall
	2S 3S 61S	4S 52S	24S	2S-O 3S-O 61S-O	2S-F 3S-F	2S-H12 3S-H12	2S-H14 3S-H14	2S-H16 3S-H16	2S-H18 3S-H18	4S 52S	61S-F	61S-T4 61S-T6	24S-F 24S-T3	All alloys
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10	Col. 11	Col. 12	Col. 13	Col. 14	Col. 15
5	.042	....	.058	.500	.500	.500	.500	.500	.350	....	.500	.500	.450	.400[3]
5¼	.042	....	.058	.500	.500	.500	.500	.480	.350	....	.500	.500	.450	.400[3]
5½	.042	....	.058	.500	.500	.500	.500	.450	.320	....	.500	.500	.450	.400[3]
5¾	.049	....	.058	.500	.500	.500	.500	.400	.300	....	.500	.500	.450	.400[3]
6	.049	....	.065	.500	.500	.500	.500	.400	.300	....	.500	.500	.450	.400[3]
6¼	.049	....	.065	.500	.500	.500	.500	.375	.284	....	.500	.500	.450	.400[3]
6½	.058	....	.065	.500	.500	.500	.500	.350	.259	....	.500	.500	.450	.400[3]
6¾	.058	....	.065	.500	.500	.500	.500	.320	.259	....	.500	.500	.450	.400[3]
7	.062	....	.078	.500	.500	.500	.500	.328	.250	....	.500	.500	.453	.437[3]
7¼	.062	....	.078	.500	.500	.500	.500	.328	.234	....	.500	.500	.453	.437[3]
7½	.062	....	.093	.484	.500	.500	.500	.312	.234	....	.500	.500	.453	.437[3]
7¾	.078	....	.093	.468	.500	.500	.500	.297	.218	....	.500	.500	.453	.437[3]
8	.078	....	.171	.453	.500	.500	.468	.281	.218	....	.500	.500	.453	.437[3]
8¼	.078	....	.250	.437	.500	.500	.468	.281	.203	....	.500	.500	.453	.437[3]
8½	.078	....	.281	.421	.500	.500	.437	.266	.203	....	.500	.500	.453	.437[3]
8¾	.078	....	.344	.406	.500	.500	.421	.266	.187	....	.500	.500	.421	.437[3]
9	.093	....	.406	.390	.500	.500	.421	.250	.187	....	.500	.500	.421	.437[3]
9¼	.093	....	....	.375	.500	.484	.406	.250	.187	....	.500	.500	....	.437[3]
9½	.109	....	....	.375	.500	.468	.390	.234	.171	....	.500	.500	....	.437[3]
9¾	.125	....	....	.359	.500	.453	.390	.234	.171	....	.500	.484	....	.437[3]
10	.125	....	....	.344	.500	.437	.375	.218	.171	....	.500	.468	....	.437[3]
10¼	.125	....	....	.344	.500	.437	.375	.203	....	....	.500	.453	....	.437[3]
10½	.156	....	....	.328	.500	.421	.359	....	....	....	.500	.453	....	.437[3]
10¾	.187	....	....	.312	.500	.406	.359	....	....	....	.500	.453	....	.437[3]
11	.250	....	....	....	.500	.390	.344	....	....	....	.500	.421	....	.437[3]
11¼	.312	....	....	....	.500	....	....	....	....	....	.500	.421	....	.437[3]
11½	.437	....	....	....	.500	....	....	....	....	....	.500	....	....	.437

[1]Standard wall thickness limits of tubing other-than-round are the same as those of round tubing of the same perimeter.
[2]Range, up to but not including the next larger outside diameter shown.
[3]Or the thickness shown in Cols. 5 to 14 for the alloy and temper in question, whichever is less.
[4]Requirements beyond these Standard Manufacturing Limits should be made the subject of special inquiry.

TABLE 75—COMMERCIAL[1] SIZES OF 3S, 4S AND 52S FLAT SHEET

Thickness, Inch	Maximum Rolling Limits 3S				Maximum Rolling Limits 4S		Maximum Rolling Limits 52S	
	Mill Finish		Standard Bright Finish		Mill Finish		Mill Finish	
	Width In.	Length Ft.	Width In.	Length Ft.	Width In.	Length Ft.	Width In.	Length Ft.
0.249–0.172	102	30	60	20	102	24	84(2)	24
0.171–0.136	102	30	60	20	102	24	72(2)	24
0.135–0.096	102	30	60	20	90	24	72(2)	24
0.095–0.086	90	30	60	20	72	24	72(2)	24
0.085–0.077	90	30	60	20	66	24	72(2)	24
0.076–0.068	90	30	60	20	60	20	60(2)	20
0.067–0.061	84	24	60	20	60	20	60(2)	20
0.060–0.054	84 76 60	16 20 30	60	20	60	20	60(2)	20
0.053–0.048	84 76 60	16 20 30	60	20	60	14	60(2)	14

[1]Refer to Table 66 for Alcoa Mill Standard Sizes.
[2]Maximum width in H38 temper is 54 inches and in H36 is 60 inches.

TABLE 76—COMMERCIAL[1] SIZES OF ALCLAD 14S, 24S, ALCLAD 24S AND 61S ALLOY FLAT SHEET

Thickness, Inch	Alclad 14S		24S and Alclad 24S		61S	
	Maximum Rolling Limits		Maximum Rolling Limits		Maximum Rolling Limits	
	Width Inches	Length Feet	Width Inches	Length Feet	Width Inches	Length Feet
0.249–0.096	60	24	60	24	102	24
0.095–0.068	60	24	60	24	90	24
0.067–0.061	60	24	60	24	84	24
0.060–0.048	60	18	60	18	72	18

[1]Refer to Table 67 for Alcoa Mill Standard Sizes.

CONVERSION TABLES

AND OTHER

USEFUL DATA

USEFUL CONVERSION FACTORS

One board foot	=144	cubic inches
One centimeter	=0.3937	inch
One centimeter	=0.01	meter
One centimeter	=10	millimeters
One cubic centimeter	$=3.531 \times 10^{-5}$	cubic feet
One cubic centimeter	=0.06102	cubic inch
One cubic foot	=28317	cubic centimeters
One cubic foot	=1728	cubic inches
One cubic foot	=7.481	gallons
One cubic foot	=28.32	liters
One cubic inch	=16.39	cubic centimeters
One degree (angle)	=0.01745	radian
One foot per second	=0.6818	mile per hour
One gallon	=231	cubic inches
One gallon	=3.785	liters
One gram	$=2.205 \times 10^{-3}$	pounds
One gram per cu. cm.	=62.43	pounds per cubic foot
One horse-power	=550	foot-pounds per second
One horse-power	=0.7457	kilowatt
One inch	=2.540	centimeters
One kilogram	=1000	grams
One kilogram	=2.205	pounds
One kg. per sq. mm.	=1422	pounds per square inch
One mile	=5280	feet
One pound	=453.6	grams
One lb. per sq. in.	=0.068	atmosphere
One lb. per sq. in.	=2.307	feet of water
One lb. per sq. in.	=2.036	inches of mercury
One lb. per sq. in.	$=7.031 \times 10^{-4}$	kg. per sq. mm.
One radian	=57.30	degrees
One square inch	=6.452	square centimeters
One ton (short)	=2000	pounds
One ton (metric)	=2205	pounds
One ton (long)	=2240	pounds
One ton (long) per sq. in.	=1.575	kg. per sq. mm.

TABLE 77—FRACTIONS TO DECIMALS

Fractions					Decimals	Fractions					Decimals
				1/64	.015625					33/64	.515625
			1/32		.03125				17/32		.53125
				3/64	.046875					35/64	.546875
		1/16			.0625			9/16			.5625
				5/64	.078125					37/64	.578125
			3/32		.09375				19/32		.59375
				7/64	.109375					39/64	.609375
	1/8				.125		5/8				.625
				9/64	.140625					41/64	.640625
			5/32		.15625				21/32		.65625
				11/64	.171875					43/64	.671875
		3/16			.1875			11/16			.6875
				13/64	.203125					45/64	.703125
			7/32		.21875				23/32		.71875
				15/64	.234375					47/64	.734375
1/4					.25	3/4					.75
				17/64	.265625					49/64	.765625
			9/32		.28125				25/32		.78125
				19/64	.296875					51/64	.796875
		5/16			.3125			13/16			.8125
				21/64	.328125					53/64	.828125
			11/32		.34375				27/32		.84375
				23/64	.359375					55/64	.859375
	3/8				.375		7/8				.875
				25/64	.390625					57/64	.890625
			13/32		.40625				29/32		.90625
				27/64	.421875					59/64	.921875
		7/16			.4375			15/16			.9375
				29/64	.453125					61/64	.953125
			15/32		.46875				31/32		.96875
				31/64	.484375					63/64	.984375
1/2					.5	1					1.0

TABLE 78—INCHES TO CENTIMETERS

One Foot = 30.480 Centimeters

	0	1	2	3	4	5	6	7	8	9	10	11
0	0	2.540	5.080	7.620	10.160	12.700	15.240	17.780	20.320	22.860	25.400	27.940
1/32	0.079	2.619	5.159	7.699	10.239	12.779	15.319	17.859	20.399	22.939	25.479	28.019
1/16	0.159	2.699	5.239	7.779	10.319	12.859	15.399	17.939	20.479	23.019	25.559	28.099
3/32	0.238	2.778	5.318	7.858	10.398	12.938	15.478	18.018	20.558	23.098	25.638	28.178
1/8	0.318	2.858	5.398	7.938	10.478	13.018	15.558	18.098	20.638	23.178	25.718	28.258
5/32	0.397	2.937	5.477	8.017	10.557	13.097	15.637	18.177	20.717	23.257	25.797	28.337
3/16	0.476	3.016	5.556	8.096	10.636	13.176	15.716	18.256	20.796	23.336	25.876	28.416
7/32	0.556	3.096	5.636	8.176	10.716	13.256	15.796	18.336	20.876	23.416	25.956	28.496
1/4	0.635	3.175	5.715	8.255	10.795	13.335	15.875	18.415	20.955	23.495	26.035	28.575
9/32	0.714	3.254	5.794	8.334	10.874	13.414	15.954	18.494	21.034	23.574	26.114	28.654
5/16	0.794	3.334	5.874	8.414	10.954	13.494	16.034	18.574	21.114	23.654	26.194	28.734
11/32	0.873	3.413	5.953	8.493	11.033	13.573	16.113	18.653	21.193	23.733	26.273	28.813
3/8	0.953	3.493	6.033	8.573	11.113	13.653	16.193	18.733	21.273	23.813	26.353	28.893
13/32	1.032	3.572	6.112	8.652	11.192	13.732	16.272	18.812	21.352	23.892	26.432	28.972
7/16	1.111	3.651	6.191	8.731	11.271	13.811	16.351	18.891	21.431	23.971	26.511	29.051
15/32	1.191	3.731	6.271	8.811	11.351	13.891	16.431	18.971	21.511	24.051	26.591	29.131
1/2	1.270	3.810	6.350	8.890	11.430	13.970	16.510	19.050	21.590	24.130	26.670	29.210
17/32	1.349	3.889	6.429	8.969	11.509	14.049	16.589	19.129	21.669	24.209	26.749	29.289
9/16	1.429	3.969	6.509	9.049	11.589	14.129	16.669	19.209	21.749	24.289	26.829	29.369
19/32	1.508	4.048	6.588	9.128	11.668	14.208	16.748	19.288	21.828	24.368	26.908	29.448
5/8	1.588	4.128	6.668	9.208	11.748	14.288	16.828	19.368	21.908	24.448	26.988	29.528
21/32	1.667	4.207	6.747	9.287	11.827	14.367	16.907	19.447	21.987	24.527	27.067	29.607
11/16	1.746	4.286	6.826	9.366	11.906	14.446	16.986	19.526	22.066	24.606	27.146	29.686
23/32	1.826	4.366	6.906	9.446	11.986	14.526	17.066	19.606	22.146	24.686	27.226	29.766
3/4	1.905	4.445	6.985	9.525	12.065	14.605	17.145	19.685	22.225	24.765	27.305	29.845
25/32	1.984	4.524	7.064	9.604	12.144	14.684	17.224	19.764	22.304	24.844	27.384	29.924
13/16	2.064	4.604	7.144	9.684	12.224	14.764	17.304	19.844	22.384	24.924	27.464	30.004
27/32	2.143	4.683	7.223	9.763	12.303	14.843	17.383	19.923	22.463	25.003	27.543	30.083
7/8	2.223	4.763	7.303	9.843	12.383	14.923	17.463	20.003	22.543	25.083	27.623	30.163
29/32	2.302	4.842	7.382	9.922	12.462	15.002	17.542	20.082	22.622	25.162	27.702	30.242
15/16	2.381	4.921	7.461	10.001	12.541	15.081	17.621	20.161	22.701	25.241	27.781	30.321
31/32	2.461	5.001	7.541	10.081	12.621	15.161	17.701	20.241	22.781	25.321	27.861	30.401

TABLE 79—INCHES TO DECIMALS OF A FOOT

	0	1	2	3	4	5	6	7	8	9	10	11
0	0	.0833	.1667	.2500	.3333	.4167	.5000	.5833	.6667	.7500	.8333	.9167
1/16	.0052	.0885	.1719	.2552	.3385	.4219	.5052	.5885	.6719	.7552	.8385	.9219
1/8	.0104	.0938	.1771	.2604	.3438	.4271	.5104	.5938	.6771	.7604	.8438	.9271
3/16	.0156	.0990	.1823	.2656	.3490	.4323	.5156	.5990	.6823	.7656	.8490	.9323
1/4	.0208	.1042	.1875	.2708	.3542	.4375	.5208	.6042	.6875	.7708	.8542	.9375
5/16	.0260	.1094	.1927	.2760	.3594	.4427	.5260	.6094	.6927	.7760	.8594	.9427
3/8	.0313	.1146	.1979	.2813	.3646	.4479	.5313	.6146	.6979	.7813	.8646	.9479
7/16	.0365	.1198	.2031	.2865	.3698	.4531	.5365	.6198	.7031	.7865	.8698	.9531
1/2	.0417	.1250	.2083	.2917	.3750	.4583	.5417	.6250	.7083	.7917	.8750	.9583
9/16	.0469	.1302	.2135	.2969	.3802	.4635	.5469	.6302	.7135	.7969	.8802	.9635
5/8	.0521	.1354	.2188	.3021	.3854	.4688	.5521	.6354	.7188	.8021	.8854	.9688
11/16	.0573	.1406	.2240	.3073	.3906	.4740	.5573	.6406	.7240	.8073	.8906	.9740
3/4	.0625	.1458	.2292	.3125	.3958	.4792	.5625	.6458	.7292	.8125	.8958	.9792
13/16	.0677	.1510	.2344	.3177	.4010	.4844	.5677	.6510	.7344	.8177	.9010	.9844
7/8	.0729	.1563	.2396	.3229	.4063	.4896	.5729	.6563	.7396	.8229	.9063	.9896
15/16	.0781	.1615	.2448	.3281	.4115	.4948	.5781	.6615	.7448	.8281	.9115	.9948

TABLE 80—SHEET AND TUBE GAGES

Gage number	Thickness in inches		Gage number	Thickness in inches		Gage number	Thickness in inches	
	(B & S gage) Sheet	(Stubs gage) Tubing		(B & S gage) Sheet	(Stubs gage) Tubing		(B & S gage) Sheet	(Stubs gage) Tubing
00	0.365	0.380	11	0.091	0.120	23	0.023	0.025
0	0.325	0.340	12	0.081	0.109	24	0.020	0.022
1	0.289	0.300	13	0.072	0.095	25	0.018	0.020
2	0.258	0.284	14	0.064	0.083	26	0.016	0.018
3	0.229	0.259	15	0.057	0.072	27	0.014	0.016
4	0.204	0.238	16	0.051	0.065	28	0.013	0.014
5	0.182	0.220	17	0.045	0.058	29	0.011	0.013
6	0.162	0.203	18	0.040	0.049	30	0.010	0.012
7	0.144	0.180	19	0.036	0.042	31	0.009	0.010
8	0.128	0.165	20	0.032	0.035	32	0.008	0.009
9	0.114	0.148	21	0.028	0.032	33	0.007	0.008
10	0.102	0.134	22	0.025	0.028	34	0.006	0.007

TABLE 81—TYPICAL PROPERTIES OF VARIOUS COMMON MATERIALS

Material	Weight Lb./cu. ft.	Tensile Strength Lb./sq. in.	Yield Point Lb./sq. in.	Elongation PerCent in 2 Inches	Shear Strength Lb./sq. in.	Modulus of Elasticity Lb./sq. in.	Poisson's Ratio	Coefficient of Expansion per degree F. 68°-212°	Specific heat Calories per gram	Thermal Conductivity[1] 100° C.	Electrical Conductivity[2] 20 C.
Aluminum (commercially pure)	See Tables 3 and 4 for values for various alloys.					10,000,000	0.33	0.0000133	0.23	0.52	58
Brass: 34% Zn hard sheet	521	76,000	......	7	......	15,000,000	0.33	0.000011	0.086	0.20	25
annealed sheet	521	46,000	......	64	......	15,000,000	0.33	0.000011	0.086	0.20	25
40% Zn, sand-cast	521	46,000	22,000	15	......	13,000,000	0.36	0.000010	0.086	0.20	25
Bronze: 8% Sn, hard sheet	548	90,000	......	..	......	17,000,000	0.33	0.000010	0.086	0.18	23
.03%-.25% P annealed sheet	548	50,000	25,000	25	......	17,000,000	0.33	0.000010	0.086	....	23
10.5% Sn, 0.5% P—cast	...	31,000	......	8	......	17,000,000	0.33	0.000010	0.086	....	23
Copper (pure): hard sheet	557	60,000	24,000	8	24,000	17,500,000	0.33	0.000009	0.101	0.92	..
annealed	557	40,000	10,000	45	10,000	17,500,000	0.33	0.000009	0.101	0.92	97
Iron: gray cast	450	21,000	......	..	......	12,000,000	0.25	0.000006	0.115	0.10	..
wrought plate	480	48,000	27,000	25	40,000	25,000,000	0.28	0.000006	0.115	0.14	17
Lead: chemical, cast	710	2,800	......	50	......	2,600,000	0.43	0.000017	0.034	0.08	8
rolled	710	3,300	......	..	......	....	....	....	0.034	0.08	8
Monel metal: hard sheet	550	100,000	90,000	8	87,000	25,000,000	0.39	0.000008	0.128	0.06	4
hot-rolled plate or cast	550	70,000	30,000	30	46,000	25,000,000	0.39	0.000008	0.128	0.06	4
Steel: carbon, cast, annealed	490	75,000	41,000	24	60,000	29,000,000	0.30	0.000007	0.118	0.12	15
structural	490	65,000	33,000	22	48,000	29,000,000	0.30	0.000007	0.118	0.12	15
5% Ni, 0.3% C.	490	95,000	65,000	28	......	28,000,000	0.30	....	.....	0.12	..
Wood: oak	45	8,000	......	..	1,300	1,300,000	....	0.000003	0.33	0.00035	..
spruce	27	5,500	......	..	780	1,200,000	....	0.000003	0.33	0.00030	..
yellow pine	27	5,000	......	..	700	1,000,000	....	....	0.33	0.00030	..
Zinc: cold rolled; 1% Cu, 0.01% Mg	440	37,000	......	20	......	....	0.11	0.000018	0.092	0.27	..

[1]Calories transmitted per second through a plate one centimeter thick per square centimeter of its surface when the difference of temperature between the two faces of the plate is one degree centigrade.
[2]Volume conductivity in per cent based on 100 for copper (International Annealed Copper Standard).

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The Davenport Story

For information, write Motion Picture Dept., Aluminum Company of America, Pittsburgh 19, Pa.

PRODUCTS

Ingots

Ingots, billets and slabs for wrought aluminum products.

Casting alloy ingot.

Metallurgical granulated ingot.

* * *

Materials for Fabrication

Rolled structural shapes: Angles, beams, channels, car channels and zees.

Extruded shapes and moldings for aircraft, architecture, railroad rolling stock, truck bodies, bus bodies, etc.

Rod and Bar: Round, rectangular, hexagonal and special shapes for screw machine stock, etc.

Plate: Sheared and sawed, rectangular, circles and tread.

Tank plates.

Tread plate.

Sheet: Alclad, flat, coiled, corrugated, circles, reflector sheet and roofing sheet.

Handrails and fittings.

Pipe and fittings (I. P. S.).

Tubing: Round, square, streamline and special shapes.

Castings: Sand, die and permanent mold.

Hammer Forgings.

Press Forgings.

Impact extrusion products.

Draw press products.

Screw machine products.

Rivets.

Bolts.

Nuts.

Nails.

Screws: Machine and wood.

Wire: Round, half round, oval, half oval, square, rectangular, hexagonal and octagonal and flattened.

Welding and brazing flux and wire.

Specialties

Barrels and shipping containers.

Chemical and special apparatus.

Kettles.

Tanks: Welded and riveted.

Job-shop products.

* * *

Automotive Products

Lynite pistons and connecting rods.

Lynite Lo-Ex pistons.

* * *

Electrical Conductors and Accessories

Electrical cable: All-aluminum and A. C. S. R. (Aluminum cable steel reinforced).

Cable fittings and accessories.

Rigid conduit.

Electrical metallic tubing.

Bus bars: Flat, tubular and rolled channel.

Bus bar fittings and accessories.

Fuse wire.

Magnet wire.

* * *

Paste and Powder

Paste and powder: For paint pigment, printing ink, lithographic ink, rubber compounding, dusting, etc.

* * *

Packaging Products

Bottle closures and bottle sealing machines.

Collapsible tubes.

Foil: Plain, printed, embossed, lacquered and paper-mounted.

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AKRON 8, OHIO	506 Akron Savings & Loan Bldg.
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ALLENTOWN, PA.	913 Hamilton St.
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ALUMINUM COMPANY OF AMERICA

General Offices—Gulf Building, Pittsburgh 19, Pa.

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